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THOUGHTS

ON

MATTER AND FORCE:

OR,

MARVELS THAT ENCOMPASS US:

COMPRISING

SUGGESTIONS ILLUSTRATIVE OF THE THEORY OF THE EARTH AND OF THE UNIVERSE.

BY THOMAS EWBANK,

AUTHOR OF "HYDRAULICS AND MECHANICS," "THE WORLD A WORKSHOP," "LIFE IN BRAZIL," ETC.

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PREFACE.

DIVERSITY of genius and tastes, of mental conformation and power, is the basis of general progress. The temple of science is not to be built up by one class of thinkers, nor that of the arts by one set of workmen. There is employment specially adapted for every class. Some minds exclude, and others are slow to admit conjecture in departments belonging to demonstrative knowledge. Others, again, are led to theorize on the possible and probable, in connexion with the actual; and they are also right, for thought is not intended to be confined by lines and angles, nor is the science of quantity necessary to an appreciation of the wonders that environ us. Astronomy presents the grandest of problems to mathematicians, but there is something more in it than can be weighed and measured. Then, natural phenomena are open to common apprehensions, and when viewed without the aid of science suggest hints valuable to the learned. Fresh truths, like fresh fires, have been kindled by insignificant sparks.

With great diffidence this desultory paper is submitted to the consideration of scientific men. I am painfully sensible of its defects, and assuredly, nothing but the consciousness that nature has always new things to reveal, and that every attentive observer may pick up something overlooked by others, could have sent it to the printer.

Whatever may conflict with accepted theories is propounded, not affirmed; and if the language occasionally borders on assertion, the blemish is attributable to poverty of expression, not to a positive spirit. Still, I had rather be author of novel heresies in science, than remain satisfied with what has been gained; for new views, if even erroneous, are indirect aids to discovery. There is fruit to be gathered out of beaten tracks; and while he who refuses to leave them may

retail current doctrines, like a shopman other men's goods, he will rarely contribute a fresh one of his own.

Of propositions deemed (perhaps erroneously) more or less new or newly illustrated, the following among others may be named:

The first movement of matter the rotation of the whole, and the form and motion of the spheres a corollary of that movement.

Orbital are axial motions developed in a diminishing series, and have therefore a common origin with the latter.

Heat is the product of the concrete spheres, and was consequently undeveloped in the fluid universe.

Every orb is, by the compression of its materials, a perpetual friction-fire-mill.

The circulation or interchange of internal and external matter in the spheres, a cardinal and universal principle—the cause that arrests condensation and secures permanency to planetary and solar volumes.

The central expanding or upheaving power in planets essential to vegetation, to life, and the Arts.

Specific heats are natural temperatures due to diverse intensities of molecular motion.

Properties of matter merge into their opposites, as exemplified in condensation giving rise to expansion.

It is movable atoms that make movable masses.

Circular motion the parent and most perfect of all motions.

All forces, except gravitation, originate in heat in the spheres.

Expansion, positive force; contraction, negative force.

Universal circulation of matter through all forms and conditions.

Varieties of forms and qualities interminable as the permutation of atoms.

Degrees of tenuity in motive fluids of living and other forces.

Motion increased with every sub-division of celestial masses. The planets circulate round the sun and at the same time keep up with him in his progress through space. Moons sweep round planets and are not left behind them.

All motions are frictional, and give out heat.

The heat of the present universe is the effect of friction arising from the compression of its materials, and represents the force of the universe: or in other words, gravitation is the weight that moves the clockwork of creation, and by its offspring, heat, is ever winding it up.

NEW YORK, *Dec.* 1857.

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THOUGHTS ON MATTER AND FORCE.

CHAPTER I.

Two entities—Creation a Museum of wonders—Its whole material in the firmament—Artless exterior of the universe—Explorations into the infinite justifiable—No law forbidding investigation of natural phenomena—Space charged with matter—Amount of matter invariable—Separated into the fluid in space, and the concrete in the spheres—The former gelid and of equal tenuity—Why the spheres are concrete; their permanency of form and volume and uniform motions—Their illumination—The greatest part of matter in suns—Their distribution in space—A central sun—Reasons why matter was not gathered into one universal orb.

THERE are, it is supposed, but two absolute entities—Matter and Spirit—though some metaphysicians think there is but one. Of their real nature the Creator alone is cognizant. Matter is only partially palpable to sense. In some conditions it melts away as if into spirit, while even its grossest forms defy analysis. No chemist can resolve a substance into its ultimate atoms and exhibit them. That mental phenomena depend on material organs is not questioned, though how, or in what manner, perception, me-

mory, will, &c., are evolved through the brain, anatomists have endeavored in vain to find out. Goltz is not the only one who has persevered till vision failed and the hand could no longer guide the scalpel. Worn out with alternations of hope and disappointment, the fabric of his understanding broke down, and in a fit of despair he expired in his dissecting room.

But without reference to ultimate causes, creation is a museum of wonders—of processes and results than which, had they not become familiar, nothing could be more astounding. Yet the world at large is as insensible to the marvels that encompass it as the lad of Elisha. It is not till the latent faculty is awakened, or, in the language of Scripture, not till our eyes are opened, that manifestations of the Deity, surprising as the horses and chariots of fire which encircled the prophet, can be perceived—manifestations obvious and palpable, not local but everywhere, not evanescent but enduring.

Can a scene be imagined surpassing that which the firmament opens? One comprising THE WHOLE MATERIAL OF CREATION, and the full exposure of the Creator's doings with it! An exhibition where no partiality as regards the sight prevails, no preferences as to location given, but where every beholder may derive instruction and entertainment as readily as any other. Among the often recited advantages of existence how is it that a spectacle, of which a momentary view would seem enough to have lived for, is not enumerated? To be admitted as spectators of the Universe, and be shown the great outlines of its plan—to perceive that its original or unelaborated material, instead of being retained in one connected mass, is broken into vast groups of

separate masses—that motion, instead of rest, is the basis of stability, and whirling spheres, instead of fixed planes, the theatres of life and of life's developments—to be borne through the heavens on this earthly chariot, with advantages equal to those enjoyed by occupants of any other sphere for observing and reflecting on these things—what more can the most aspiring crave! And yet how feebly are the sublimest of sights and the divinest of privileges appreciated!

As our emotions, arising from the contemplation of the scene, subside, they are again excited by the manner in which matter at large is disposed of; the whole being represented in two of the simplest forms and conditions—ordinary-shaped solids gliding through a fluid! Had we never till now beheld what creation outside of us was like, the impression would probably have been mingled with surprise at the plainness of the picture! For who could have conceived THE COMPLETE WORKS OF THE ALMIGHTY —the full outpourings of Himself—inclosed within so artless an exterior, or a *tout ensemble* so clear and comprehensible!

By a law to which we are subject, and which may be supposed a cosmical one, every individual, let his circumstances and condition be what they may, is to acquire knowledge for himself; for which purpose THE GREAT BOOK of instruction is never closed. I know not, nor can I imagine a privilege equal to that of contemplating whenever and wherever I wish, the material products of the Creator's thoughts, to observe the wonderful adaptations of means to ends, and of critically examining, handling, and even analysing those devices which my organization may be more

especially adapted to scrutinize. To me it appears like a pupil drawing near to his teacher and holding familiar communion with him. And how much greater the results than generally supposed! not only the discovery of facts and principles which add to the number and value of the arts of civilization, but a never-failing source of increasing mental pleasure; and, in every new truth, a fresh demonstration of the Divine agency in Nature. 'For what science is there, or can there be, which has not a reference to God? Science is thus hallowed by its relation to the Deity; and theology, instead of being a dull or repulsive study, as it cannot but be when it consists only of formularies and dogmatisms, becomes the most cheering, elevating, and instructive of all human occupations.'

As all intelligences live, move, and have their being in Him, in common with us, 'for we also are his offspring,' the reflection is a pleasing one, that while there may be classes far superior to us—such as have clearer conceptions respecting matter and mind, who better understand the mechanism of the spheres, and take in more of them at a glance—the self-same lesson which excites their attention engages ours. While every class has the internal economy of its special orb to explore, they all unite in contemplating the grandest demonstration of His character and power in the myriads of worlds without.

But is it not presumption in ephemerons like us to speak of the general features of Creation? Are not such questions too high for us? No.

The Creator has provided no shackles for the mind, but left it free to rove where it listeth. He has enacted no law forbidding inquiry into natural phenomena; on the con-

trary, every part of creation and everything belonging to it, its past and present aspects, its plainest and deepest truths, invite investigation, for with its great Author, as just observed, there is nothing secret—absolutely nothing. Knowledge of his works is limited only by the capacities of inquirers; and while thirst after knowledge is an instinct, expansion is an attribute of intellect: hence the human mind, faint and feeble as on many occasions we find it, is boundless in its aspirations, and hesitates not to attempt explorations into the Infinite.

Nor is this wrong. It is in some degree unavoidable, for there is no subject, mental or material, that is not allied to or which does not lead to the Infinite. We and all our belongings are merged in it. Were we therefore to be deterred from venturing on the ocean of inquiry for fear of losing ourselves, we should learn nothing. We have only to keep within soundings; and to embolden us there is the encouraging fact that, as we proceed, the powers of the plummet increase with the depth. It is only when we attempt to pry into extremes that our powers fail us; as, when we contemplate matter as a whole it swells into immensity, if in monads it vanishes into invisible points. And this is well; for if the limited did not lead to the illimitable, how could every order of intelligences be provided with never-ending series of progressive lessons: for that the intellect is infinitely diversified may be inferred from the fact that matter is so.

Although launched among the stars and endowed with an astonishingly wide range of vision, and that range immeasurably extended by the telescope, we have and can have but exceedingly contracted conceptions of space or of

the numbers and magnitudes of the spheres. We use words in relation to them without feeling their force: but while thousands of things connected with the material universe may never be explained, there are those that are obvious, and others which, though not demonstrable, may pretty safely be received as facts. We refer to some of them.

Space is charged with matter. Neither can be where the other is not. Is it asked, If matter be everywhere, how can one body move without disturbing another? It cannot. Matter is ordained to move *in* matter, and hence it is indispensable that masses in motion should be more dense than those they pass through.

The amount of matter is invariable—the same now that it ever was. Any change in this respect would be incompatible with stability. There is not the least reason to infer that from the beginning a new particle has been created or an old one annihilated.

Matter is *divided into two distinct portions*, one constituting the ether, and the other the spheres floating in it. What proportion the amount invested in orbs bears to that diffused in free space we cannot tell. That it is a definite one there can be no doubt, since it affects the entire fabric of creation. It unquestionably is in perfect harmony with the functions assigned to the fluid and concrete, and with an universal law of adaptation, economy, and results. Were the density of the etherial fluid known, a comparison might be instituted of the proximate amount of matter compressed into the orbs of the solar system, and that dilated in the space they occupy, and thence the density of the primordial nebula might be deduced.

Essential to the growth and conservation as to the embry-

onic development of the spheres, the etherial fluid serves them as a medium to move in, from the centre to the circumference of infinity. If it be not a supporter of stellar combustion, it certainly plays an important part in the circulation of heat and light through the heavens. Its low temperature is significant. As the spheres are condensed fluids, a heated medium would tend to dissolve them into their original gaseous forms; hence the extreme frigidness of the bath, and the perpetual immersion of the planets in it; they neither abstract heat from nor impart any to the ether. But for its gelidity planets would gradually swell into nebulæ, and fill the areas comprised within their orbits —the universe would be resolved into its elements.

However attenuated this fluid, we may suppose it retains the mechanical properties of fluids; hence currents induced by stars and their trains rushing through it, and the ceaseless interchange of place of its elements: the portion through which the earth is at this moment passing may, for aught we know, have been swept over by the Pleiads, and by constellations antipodal to the Pleiads.

Invisible and intangible, the ether consists of the same elements as the spheres. Collected out of it, they were condensed around nuclei, till what was left was sufficiently dilated to accord with their free movements in it. Its tenuity agrees with this. The velocity of light probably could not have been what it is, if it had been required to traverse a thicker medium; nor that of the spheres either.

It is assumed to be uniform in density, since, were it not so, irregularity in the movements of the spheres might occur. Would they not be hastened through subtle and retarded in

thick strata; and their speed checked in passing out of one and entering another?

There is a significant fact bearing on this point. As heat expands all forms of matter, and as fluids are peculiarly sensitive to it, if the ether were subject to local expansions from changes of temperature, its resistance to bodies passing through it would vary. Now, it appears that solar rays do not disturb its equilibrium. They reveal not their virtue till they strike the surface of the planets. This mode of transmitting heat over the vastest spaces without losing any by the way, is characteristic of celestial power. With us it is incapable of transmission without dispersion.

We behold matter in three general conditions—solid, liquid, and aeriform or gaseous. These are somewhat indefinite, the lines between them being frequently indeterminable, merging as they do into each other. Not one is permanent; hence they are incidental states or conditions through which matter passes. If any one is natural it must be the gaseous, since in that state atoms were necessarily first collected into masses.

Why the spheres are solid bodies will now have appeared. The extreme conditions of matter are the aeriform and concrete—liquidity being an intermediate or transition state. Now, as the details of creation were to be wrought out by *expansion* upon the spheres, we perceive the reason why they should be solid bodies, viz. that by the dilatation of concrete matter, liquid and gaseous developments in all their varieties might be added to those of the solids. This could not have been the case had the spheres consisted only of liquid and gaseous, or of solid and liquid matter. In either case creation had been a very different affair to what it is;

one inconceivably less varied in its forms, qualities, and movements.

What the spheres were made for.—We hold it an instinctive or intuitive truth that the spheres are designed as homes for sentient beings, and we should believe this had not those in our vicinity changes of seasons and natural periods for labor and repose, like our own. We mention this because it is, we think, manifest in the special forms and movements which the Great Builder has given to his material. Permanency of form and regularity of movement are essential to every inhabited mass, since otherwise there could be no reliance on qualities and applications of diverse substances; hence solid orbs, and with circular outlines that in no position angles might be presented to the resisting fluid medium.

It is very obvious that inhabited spheres should be comparatively at rest, since, were they not so, nothing could be permanent or stable upon them. Now as it is impossible for any parcel of matter to be absolutely at rest—that being incompatible with its nature and with the constitution of the universe—what is the fact? Why that the spheres have motions so uniform as to be equivalent to a state of rest. Did we not know that our earth was rushing through space, we could not have suspected from anything occurring upon it that it moved at all.

Had we not been in the habit of observing the same bodies moving and ceasing to move, we could have had little or no knowledge of either force or motion, for ceaseless motion could no more have suggested either than unbroken repose. The spheres were to form bases of operations requiring fixed foundations, and how beautifully is this

accomplished! Buildings on this little orb of ours are as stable as if it moved not.

Permanency of volume is also indispensable, and that also is secured, as will be explained further on.

That they should be illuminated was another necessity; and what is more admirable than the mode by which this is done? Space was a dark and dreary abyss. How were the spheres to traverse it without light and to what purpose? Creation was designed to communicate intelligence and happiness to sentient beings, but how limited and low must both mental and material enjoyments have been if the 'darkness on the face of the deep' had remained until now! We should have been troglodytes—creeping on or burrowing in the ground, insensible to the wonders about us and wholly ignorant of all beyond us—or rather, we had not been, for constituted as we are we could not have existed.

While details in the illumination of the Universe may be infinite, and the intensities of effulgence also, the outlines or general features of the system are obvious:—Primordial darkness has been dispelled and the highway of worlds lighted up, by the suspension of Astral Lamps in the universal dome. The chief of human efforts in projecting light are the beacons for the guidance of ships approaching land in the dark, and with what costly combinations of science and art is a mere handful of rays thrown a few leagues out to sea! But by the light-houses of the skies the whole of that ocean which has neither bottom nor shore is irradiated—every sun being a fountain of luminous rays and every planet a reflecting lens.

Our solar orb bathes the worlds in his district in perpetual radiance, though the nearest is located millions of miles from

him, and the furthest multiplied millions! But the spaces between the stars, or that between us and the nearest one, no sagacity can determine. All that science has done is to prove that the nearest one cannot be *less* than two hundred billions of miles from us: how much *more*, there are no data by which to calculate. Here the most gifted minds are baffled and thrown back on themselves, on attempting a short step into the temple of the universe. And how vast the dome of that temple, when attempts to realize the simple distance between two neighboring hanging lamps, stretch the highest faculties to their utmost tension, and stretch them in vain.

The greater part of the material of Creation is in Suns. Planetarians as we are, we might be led to contemplate suns as special and planets as ordinary abodes of life and intelligence, but there are stronger reasons for reversing the proposition. By far the greater portion of the material of creation is gathered into suns. Beyond our system nothing else is seen. Satellites, whether few or many, are too small to be detected; and if they could be made out, the matter in them would be found to bear, as here, a small proportion to that of their respective primaries. At any rate, as an assemblage of habitations it is the stars that give character to the universe. Planets, compared to suns, are mere islands on the coasts of continents. The idea that stars are simply lights, and not fitted for the abodes of moral beings, can hardly now be entertained. We do not make candles larger than our dwellings, nor does it seem possible for the Creator to expend more material on his lamps than on buildings to be lighted up by them.

Distribution of concrete matter through space.—It may be

thought that as the section of the heavens over us, vast as it is, is only a minute portion of the whole, the character of the landscape may differ elsewhere. It may; but the probabilities are that matter is pretty equally distributed, that intervening spaces increase and diminish with the masses of the spheres. The appearance of things in our firmament may seem to conflict with this, but is not inconsistent with it. At all events, it is impossible to imagine any other disposal of matter than in revolving masses; and though their groupings may admit of diverse modifications, there may be as great a variety of these within our field of view—which is being constantly extended—as in any other. There is no great reason to infer that the prospect is anywhere essentially different from what it is here.

On this subject there seems to be an increasing inclination to adopt a questionable hypothesis—we say questionable, although consonant to the theory of attraction, and, as some would think, required by it:—As one sphere forms a centre of motion for a number of smaller ones, it has been suggested that the principle extends through a swelling series till the whole circulate about ONE VAST CENTRAL SUN, whose influence is to constellations what that of our sun is to his satellites. The general movement of the sidereal heavens is thought to confirm it. Our sun contains seven or eight hundred times more matter than all his satellites together; a proportion most likely varied outside of our system, and may not be the same in any two systems, but whatever may be the supposed central orb it must needs, according to the theory of attraction, require vastly more than half the material of the Universe.

Another idea:—When we reflect on the distribution of

matter; behold it scattered through space in innumerable masses and the firmament charged with the finest particles, as with the dust arising from the chiselling of the spheres; and these separated by impassable gulfs so that the occupants of one can hold no communion with those of another, the thought is apt to intrude—Why not have collected the material into ONE UNIVERSAL ORB, and united upon it in one family all intelligences? Though we know not the workings of the Divine mind on the origin of Creation, we find no difficulty, maugre the bluntness of human perception, in discovering proofs of the superiority of the existing plan over any other that man can imagine.

If all creatures were to occupy one sphere they would have to be constituted alike, but diversity is the law of organic and inorganic formations; and hence, with every change in the masses or volumes of worlds, their occupants and products change also. If there were but a single species of material intelligences one orb might have sufficed, not otherwise. If all matter had been gathered into one, *we* had not existed; and, from the known laws of gravitation, no inhabitant of any part of the present heavens could have lived an instant upon it. If intellect be infinitely varied, so must the habitations of intellect; and that this is so, would appear from the apparent fact that no two constellations, systems, or single orbs, are alike in all things nor probably in anything.

Another reason why the Creator made up his materials in various-sized parcels, we may presume was, that *more room* was thereby attained for the accommodation of living beings. Economy is a law of God. There is nothing superfluous in his works, and everything is made to produce maximum

results. Now, if all matter had been consolidated in a single mass, its surface would have been limited, though vast beyond finite comprehension. The division into existing spheres furnishes dwelling-space inconceivably more extended, and provision is made for an infinitely greater variety of creatures to enjoy life, and for infinitely greater numbers of each variety, than could be crowded or sustained upon a single orb.

It may be said, the diversity of creatures on our little orb is exceedingly great. True, but every species is confined in its developments within narrow limits. This is eminently the case with our own, and so it would be were there an universal orb. And while the varieties in such an one would surpass our imaginings, still the richness of its minerals, its fauna and flora, would really be indigence compared to the opulence of variety which the countless assemblages of existing orbs must disclose.

In a single sphere the bulk of all matter would be buried and unavailable, because out of the reach of finite efforts. An eternity of mining could not explore its interior, and metals could only be attained at the surface, if attainable at all; whereas, by the present plan, no more matter is used in each orb than is productive, and metals and other materials, essential to progressive science and arts, are within practicable distances, and attainable with moderate exertion. [See *The World a Workshop:* New York, 1855.]

There are, of course, moral as well as physical reasons for the existing disposition of matter, but they would be out of place here.

CHAPTER II.

Matter mysterious as spirit—Atoms and their properties—Their all-pervading influence and universal circulation—Matter little thought of—Its metamorphoses surpass in interest the wildest imagination—Examples—Provision for diversity of developments—Minerals, vegetables, and animals, preparing material for one another—Geological and astronomical sources of change—Dissolution and renewal of worlds—Transfigurations of matter interminable as the permutation of its atoms—How the infinitely varied objects in nature are exhibited in relief, without one being isolated or cut off from another.

But the material, the crude material of Creation, must, in itself, be of extreme interest. Provided by the Deity expressly for the work, and embued with every requisite quality, it may be supposed to bear his impress. And it does. Although we are ever handling and employing it, it is in its origin and essence as mysterious as spirit. If we knew what it is, we could better comprehend the things made of it. But there is no decomposing it. Its elements elude us as effectually as if they existed not. In the Protean forms it puts on we are often at a loss to distinguish between the real and incidental—between cause and effect.

In the absence of evidence amenable to sense, respecting things that can never be seen, it has been assumed that the elements or atoms of matter are uniform in figure, size, qualities, and inconceivably minute. By abrasion we reduce substances to impalpable dust; but a grain of the finest, com-

pared to an ultimate atom, is probable as a mountain to a mustard seed. No microscope can swell one into sight, for we can never grasp the infinite in minuteness any more than in magnitude. No acid can corrode, no friction wear, no heat fuse, nor violence disfigure them; unchangeable, impenetrable, indestructible. They are probably spherical, and move equally freely in all directions. Masses of them, when free, arrange themselves in globules and globes.

Some have thought them enveloped each in an elastic *aura* of caloric, by means of which they are supposed to push themselves apart and form gases—to draw near till they constitute liquids, and still nearer when they cohere in solid bodies; repulsion being the alleged basis of fluidity, and cohesion that of solidity—chemical affinity, with all its marvellous manifestations, presenting different phases of these opposing and yet harmonizing properties.

It is usual to consider a *molecule* as containing a number of atoms, and a *particle* a number of molecules, but in this general view we shall use these terms indiscriminately. Some writers suppose there is a variety of atoms, each kind having a particular form and magnitude; that a definite number of these combine with a determinate number of others and form compound molecules, with properties differing from those of their constituents.

As the character of an edifice depends upon its materials, so does that of the universe on these units of which it is built. Their influence pervades every sphere, and is felt in the tone, color, and constitution of everything. Even the extent of the structure is governed by them, for the indefinitely large can only arise from the indefinitely small. Had the size of atoms been limited, so had the forms and proper-

ties of bodies; nor could there have been unlimited degrees of force or motion.

The universal circulation of atoms is probably a fundamental principle in the plan of creation. It is apparently impossible for any to be long confined to one substance or one place. All bodies, both while growing and decaying, cease not to throw them off in exchange for others, so that it is not only possible but probable that every earthly atom passes through every earthly form, and even exchanges places with those constituting the ether and the stars. Molecules beyond the confines of our system may once have been active in human bodies, and those in the air we breathe, inhaled by occupants of southern constellations. Our globe, like every other, has an atmosphere which receives its exhalations and prepares them to enter into fresh combinations, and whence they are withdrawn to form them; so the stellar firmament may be viewed as the atmospheric laboratory of the universe—the reservoir out of which the spheres were gathered, the receptacle of their emanations, and the everlasting source whence they may recover what they throw off.

The study of matter is the special business of physical intelligences. As for ourselves, we are made of it, we eat it, drink it, inhale it, and upon our acquaintance with it rests our mental and moral status—our highest pleasures and greatest good. Yet what apathy is manifested towards it! Amid the business and bustle of life it is forgotten, or viewed with indifference. Except in articles of merchandise, scarcely one individual in ten thousand pauses to give it a thought. It is, as a general thing, understood to possess useful properties, and capable of convenient applications, beyond which nothing specially noticeable is perceived or suspected in it!

But with those that pry into this common thing, the conviction grows that the most gifted intellects can never fathom a tythe of the mysteries hidden in it, or trace to their source the simplest of its manifestations. For instance, how incomprehensible its metamorphoses! All substances made out of the same materials! One class of bodies shapeless, insensible, and inert, another captivating in form, colors, and odors; in others the material is pervaded with appetites, and then, instead of silently lying or growing on one spot, it leaps, runs, screams, climbs, and fights to gratify them.

There is nothing too wonderful to believe respecting its changes of forms and qualities. The wildest imaginations are left immeasurably behind. Passing by its diverse aspects in our bodies: solid in bones, liquid in blood, hair on the head, ivory in the teeth, horn in the nails, &c., in what a multiplicity of substances it ministers to us daily! We rise in the morning and behold it as stone or brick in the walls, wood on the floor, plaster on the ceiling, glass in the windows, marble in the mantels, iron in the grate, air in the room, and gas in the pipes. We are cold, and as fuel it warms us; the shutters are closed, and it gives us light. It is water in the basin and soap on the washstand. As cotton, flax, silk, and wool, it awaits us in articles of furniture and apparel; we tread on carpets and recline on sofas; for purposes of the toilet it serves us in mirrors, razors, scissors, pins, combs, and brushes, in gems and jewelry, cosmetics and perfumes—ever changing its forms and qualities with the services required of it!

We are hungry, and in how many guises it offers itself as food! In roots, fruits, fish, fowls, and the flesh of quadrupeds; bread, condiments, and in a thousand made dishes!

In the table it is mahogany, maple in chairs, porcelain in the plates, crystals in tumblers, steel in the knives, silver in the forks. As the vapor of hyson it rises from one vessel and exhales in the aroma of coffee from another; while the waiters, black or white, are made of the self-same elements as the dishes they serve up!

Pride may boast of gentle and of royal blood, but science shows that Alfred and Hereward were formed of the same ingredients as Gurth, and as the grunters he tended and the mast they fattened on.

Diversity of development is manifest in everything, and the provision made for it is very evident in the disposition of matter at large. Take for example the solar system. It contains a certain amount of material, which was to produce a maximum variety of mineral, vegetable, and living forms. The larger part was assigned to the sun, and the remainder to smaller bodies. Suppose the smaller portion had been gathered into a single planet, it would have been capable only of such developments as a mass in that condition could produce, which would have been comparatively few. Diversities of condition of planetary matter, and consequently of its developments, imply diversities of *volume*, *density*, *distance from the sun*, of *axial* and *orbital velocities*, and *reflecting power*. Every one of these—and there may be others—opens fertile sources of special developments, besides modifying such as are common.

Look at the facts: Instead of one, the material is gathered into a great number of planets and their secondaries or moons, thus providing two sources of variety in the mere division of the mass. Then as regards dimensions, solidity, movements, spaces between them and their solar centre, &c.,

not two are alike. Take the last element of change as an illustration of the rest: Instead of being arranged in one circle—heated, illumined, and influenced alike by the sun—they move round him in an enlarging series of circles, and not two, primary or secondary, in the same circle, or same sized circle. And now take our little changes of seasons for data, and try to imagine the extent to which planetary matter and its products are thus varied between Mercury and Neptune.

The metamorphoses of matter are not instantaneous. Time is required to throw off one mask and put on another, but it apparently admits of infinite extensions. While matter is therefore passing into new forms, these, whether many or few, or rapid or slow in succession, are more or less enduring. Every planet has a series to serve it for definite periods, for some degree of permanency is essential to life—at least to human life. What should we do if every shower brought forth strange vegetables, and every year strange animals? Minerals, vegetable and living forms comprise the series of mundane development, and they are ceaselessly playing, as it were, into each other's hands—one preparing material for the other.

By what means are varieties of bodies more immediately produced? By different aggregations of their molecules. True, you will say, but what induces them? External influences, as heat, light, moisture, &c. We are constantly witnessing the prompt effects of these on the earth and her products—her flora and fauna particularly; and we know from her own records that when she becomes no longer a suitable abode for portions of her vegetable and living occupants, they either become modified to accord with her

changes, or disappear and are succeeded by others adapted to them. Such is the case now. There are examples of animals dying out in our day; that is, by natural, not human interference; while of new ones to replace them, none are perhaps yet sufficiently revealed to arrest the attention of naturalists, and may not be for ages to come. Be this as it may, the law that dismisses one kind provides for the advent of another.

Besides plants and animals, we know that lakes, rivers, oceans, and continents give way to others. What is now dry land has been repeatedly covered with water. Epoch has succeeded epoch, each of unknown duration, but each characterized by new modification of vegetable and living forms: showing that motion and mutation are not accidents but elements of creation.

Are not most of us too ready to accept existing developments as a finality, especially as respects our own species? The thought is rather one of vanity than philosophy, for there is nothing in the past history of the earth, nor in the records or principles of palæontology, to sustain it. The solution, however, belongs to a distant future.

Of remoter causes of mundane mutations we are not without some knowledge. "The changes on the earth's surface which have produced the successive strata, as far as these are regular, are attributable to the progress of the perihelion point round the ecliptic; and by the precession of the equinoxes, and the progress of the perihelion rotation of the earth's orbit, the tropical zone, by very slow degrees, has changed, and is still changing its position." Then there are variations in the obliquity of the ecliptic, or of the earth's axis, which contribute to the periodical disappearance of

islands and continents, and the birth of new ones; consequently to changes of climates, of vegetable and animated forms.

Of the permanency of these and other causes that modify organic structures there is no room to doubt, and while they endure, their effects cannot cease. The provision for endless diversities is also as simple as for the development of organisms. The present condition of the earth, for example, is different from any preceding one, and cannot by any imaginable contingency be repeated. Geological mutations of the future may be as great as those of the past, but their character and results cannot be in all things the same.

If it were desirable to go further back in the series of causes, we should find these earthly related to celestial phenomena. The orbit of our globe is a miniature figure of that of the system, by which latter we are ever changing our position among the stars. What influence this may have on the earth and her sister orbs may never be known, since we can hardly imagine human history to include observations extended over periods sufficient to mark a change. The perihelion of the earth makes a revolution in about twenty-one thousand years, but it would seem to belong to a higher and longer lived order of inquirers than we are, to ascertain the point in the orbit of the system nearest to the centre round which it moves: or, if the path be not an ellipse, to determine the time required to complete a revolution.*

* It has been ascertained that the sun with his family of planets is progressing at a rate approaching half a million of miles a day towards a star in the constellation Hercules, and is describing a sidereal cycle

It is doubtless the same with all spheres and systems, and on no two of them can material development be the same, because in no two is matter under the same influences or degrees of influences.

There are no grounds for supposing worlds exempt from the law of change to which all things on them conform. From the nature of matter, perpetuity of form and condition is absolutely impossible in any mass however great or small. It is true that the spheres endure through cycles of time too vast for human comprehension, and which, for lack of adequate terms, are designated as infinite; but they are mere successive periods, like seasons, during which forms ripen and decay. As leaves of a perennial forest, there are, it may be, always some spheres maturing and others dissolving and giving up their substance to successors. Putting magnitude and duration aside, there is nothing in the judgment of philosophy more mysterious in fresh growths of worlds, than of grapes or grain, or of animated bodies.

That new orbs are forming would appear from spiral and other nebulæ apparently in process of consolidation. This, of course, implies decomposition of old orbs, unless we suppose substance for the new gathered out of etherial matter never yet embodied; an inadmissible scheme, since it involves continued diminution of density in the ether, and consequently a change in the movements of the heavenly bodies in it.

of over eighteen millions of years in duration around Alcyone, the brightest of the Pleiades. This is deemed consistent with the sun being one of a binary or multiple set, of which Alcyone, or some other orb, is its mate.

Dissolution of spheres does not necessarily infer catastrophes on living populations, for, like our earth, myriads of ages of elaboration may precede their introduction, and equal myriads be devoted to their gradual extinction.

But how does such a theory agree with that of attraction of gravitation? Would not the disappearance of a sun or a planet derange a system, and that of a system a constellation? So it would seem, and yet the fact may be perfectly consistent with the established theory. No one can suppose the integrity of the universe could be destroyed by the displacement of a minute part—be overthrown like a child's house of cards. Its plan, we may be sure, provides for the harmless extinction and renewal of worlds and systems, as for the shedding of leaves and the feathers of birds.

But be this as it may, there can be little doubt that the transmutations and transfigurations of matter are as interminable as the permutation of its atoms! Pursue this thought. Reflect on the varieties of figures, dimensions, colors, textures, actions, and attributes of organic and inorganic bodies existing at this hour not only on our earth but throughout the solar system and all systems: then follow them through cycles of changes infinite and eternal—that is, attempt to do so, and some faint ideas of this cheaply held thing called matter will begin to dawn.

There is one feature of creation which has not, that I am aware of, been noticed. Lest it should be forgotten it may be mentioned here:—

Few persons would object to the proposition that variety and beauty in creation arise from collecting the material into distinct and separate bodies: yet, strictly speaking, there are none! None, absolutely dissevered from the

general mass, nor from one another! None, however sharp in outlines, well defined by colors, or aught else! As there is no void there can be no perfectly isolated bodies. In the dilatability of matter all are joined, and through it, touch each other; hence the exceedingly interesting fact that nature's forms and substances are brought out in relief, principally by crowding more or less material into them than in the mediums they appear in—very much like those diaphanous porcelain plates on which landscapes and all kinds of figures are produced by simply varying the thickness of the parts.

CHAPTER III.

Suspension and movements of the spheres the great problem in celestial mechanics—Various speculations on their motions based chiefly on forces which did not exist in the fluid universe—Untenable hypotheses—The theory of attraction questioned by some writers—Irreconcilable with common notions of weight, action of springs and ascent of dust—Their explanation of phenomena ascribed to it—New experiment on attraction of mountains proposed—With some, weight is considered a quality not an incident, and attraction the tendency of bodies to their natural bases—Attraction not more mysterious than acknowledged properties of matter—If it exist in atoms it cannot be inactive in masses.

As the birth-place of the spheres and the theatre of their existence, the firmament presents the problem in celestial mechanics which more than any other awakens enlightened curiosity—worlds whirled round worlds without any visible connexions, and at distances often beyond our conceptions! This surpasses all that, without the sight, could have been imagined, so contrary it is to our ideas, and to our processes of communicating motion through inflexible and other material agents.

As is well known, various have been the speculations, published and unpublished, on the suspension and movements of the spheres. Some are analogical, some occult, and most of them inconclusive. Let us glance at a few: they are not without interest.

The energy that developes worlds has been likened to that which produces vegetation. Take for example a tree. Limbs radiate from the body, they push out branches, and these leaves and leaflets; blossoms appear, and in due time fruit, single and in clusters. Neither stems, twigs, leaves, nor fruit are in all points alike; all have appropriate motions and react on the bole, which revolves with the earth it rests on, with the earth is borne round the sun, and with the sun round a larger orbit. Stellar systems have been likened to fertile stems with fruit at the extremities of tendrils, trees to constellations, forests to galaxies, and general vegetation to interminable fields of space, overhung with the grandest of orbicular products. This is all very well, but it defines nothing—suggests nothing.

The idea that the spheres were launched forth as projectiles, and with an impetus derived from a special and direct exertion of Almighty Power, is a forlorn one. We know that HE is the first in the series of all causes; but he works with material means, and it is these we seek. It would be quite as reasonable, if not more so, to suppose them shot from slings and catapults by legions of seraphim and cherubim.

Among other notions is one that the spheres move by virtue of a latent *propelling* power, each having an *independent* portion of its own. If such were the case, the intention, we may suppose, was to allow them to alter their locations, and for that purpose to vary their directions and speed. But they are not known to change their positions, and they could not do so without deranging the existing order of things. The unchanging relationship as regards distance which they preserve towards each other is irre-

concileable with any scheme of cosmical power based on local and independent forces. To state such a proposition is to annihilate it. It implies the employing of an endless complexity of means and agents to accomplish that for which a simple one would, and, as we believe, does suffice.

Suppose individual spheres *could* move themselves, what is the power, how is it applied, and on what does it react? not on the *ether* surely, since as a resisting medium it would be incalculably less efficient than atmospheric air for steamers' wheels. Unless on the principle of rockets, we can imagine no force at all applicable, and we are sure no such force is employed; they leave no trains of propelling matter behind them, and if they did, unless provision was made for receiving fresh supplies, they would soon give out all and vanish.

If the sun were like a steam boiler, a generator of mechanical force, we know not how it can be applied. Reasoning from experience, the analogy utterly fails in the absence of a *point d'appui*. With us the motive fluid must have a base to *react* on, and it moreover must be inclosed on all sides except one through which it is to operate; but we look in vain for fixed fulcra and rigid chambers in the heavens.

If it be said, the boundaries of the system amount virtually to an inclosure beyond which the force cannot pass, that would not meet the exigence one way or another.

Like a spherical colander charged with steam, the sun sends out his rays in all directions. If the resistance they meet be uniform, the regularity of his motions would not be broken; but if those portions that impinge against the planets reacted on him, his movements would be disturbed—unless the planets were so disposed around him as to cause at all

times an equal resistance on opposite points of his surface—an impossibility.

Any hypothesis based on an emission of propelling matter from suns to planets is inadmissible on several accounts: The prodigious amount required is one difficulty, what becomes of it another, to say nothing of the sources of supply. We might infer that it would, when expended, be taken up by the planets or diffused in space. In one case the orbs propelled would be ever growing larger, and in the other, the ether would become too dense for them to get through it.

But suppose solar rays are material emanations and act dynamically, is their momentum sufficient to urge forward the planets as bodies are driven by wind; or to sustain them as balls are sustained on jets of air and water? Nothing of the kind. It might be said, as the amount of force is determined by multiplying the quantity of motive matter by its velocity, the largest bodies may be overcome by the smallest, and as a few globules of shot fired out of a gun may have more force than as many pounds thrown by hand, so a pencil of solar rays may give out more than a stream of rockets, or the broadside of a man-of-war. Let this be conceded, and there is another difficulty. The direction of the force is different from that of the bodies acted on. It reaches them in straight lines and they move in circles. Again, the quantity of motive material reaching them would be next to none compared to that which would pass between and miss them. If it had the requisite momentum, this waste would suffice to ignore the application.

But solar rays have neither weight nor motal inertia; at least none that the most delicate experiments can detect.

Look at the phenomenon almost at our very doors. As

an appendage to the earth the moon is so close to us that a visit to her, compared with a journey to neighboring planets, could only be likened to a traveller just stepping outside of his house. It is admitted that the same power that moves the spheres in their orbits moves them all, and by one and the same means. Now if the orbital movements of the planets are due to solar emission, how comes the earth to swing her satellite around her in the absence of any such expenditure? There is no analogy between the Earth, Jupiter, and Neptune, as motors, and the sun. The latter is a glowing furnace, they comparatively cold and passive. If a font of heat, light, electricity, &c., be necessary in him to move the planets, why not in them to move their moons? We are very sure that our moon is not driven on her course by matter radiating from the earth and impinging against her. There are no indications of the kind, and if there were, such a conjecture is inadmissible, if on no other ground than the waste of motive material. To fill the vault of heaven with it, and only an infinitesimal portion strike the intended object, would never do.

To meet such an objection, it might be suggested that the solar rays proceed from a luminous *ring* which throws them off in the general path of the planets.

As fluids are vehicles of force—tangible air projects cannon balls, few objects can resist the soft, aqueous vapor of steam, and imponderable fluids are agents of the mightiest energies—it has been surmised that cosmical power may exist somehow or other in the *ether*. But there can be no dynamic power where there are no motive currents, and none of these without changes of temperature. Besides, expansion or contraction of the etherial fluid could not pro-

duce motion in one direction more than in another. It might induce undulations—cause the waves to lash the sides of the spheres, but not to drive them on their courses.

Does this rare fluid reflect at all the force that urges the spheres through it, or does it perform any part in their propulsion? To act dynamically it must keep crowding up behind them and subsiding before them, besides accommodating its surges to their diversified masses, directions, and speed. Its extreme tenuity, its excessively low and presumed invariable temperature, if not conclusive of its passive character, is inconsistent with an active one.

All that need be said of such of these schemes and others as imply dynamic power is, that they are based on that which did not exist when the spheres were forming and acquiring their proper movements. There is no pushing-force that we know of which does not arise from expanding matter. If one mass is moved it is by the decomposition of another, but nothing of the kind characterizes the universal power. Suns cannot *propel* suns, nor planets planets, because both movers and the moved remain in one uniform condition. It is in the inanimate as in the living world, one body moves another. Like men carrying deceased friends to the grave, it is the active that impels the inert, with this difference, that the dead soon rise and become in their turn the impellers.

The established theory of cosmical movements is based on the principle that 'every particle in the universe *attracts* every other particle, with a force directly proportioned to the mass of the attracting particles and inversely to the square of the distance between them.' The common notion attached to weight renders it difficult with many to imagine

how bodies left without support do not fall of themselves; that, for example, when a loosened slate slides down a roof or a brick rattles down a chimney, when a lame man drops on losing his crutch, or victims of shipwreck sink, and bathers, seized with the cramp, go to the bottom—all are ruthlessly *pulled* down, and consequently by a power exterior to them; by one that invisibly dogs, as it were, their every step, and takes advantage of every slip.

Some philosophers have declined to accept this theory. They insist that metallic and other springs, solid or fluid, act equally in every direction; that the same amount of force to bend a bow is required when pulling the string downwards as in the opposite direction. It is replied that such experiments are too small and loose to render the phenomenon sensible, while it is manifested in mountains deflecting plumb lines; as evinced by French academicians in Peru, on the highest of the Cordilleras; and by kindred experiments on mountains in Great Britain and France. But the objectors question the reliability of these, and the inference, respecting the density of the earth, drawn from them. They think the constant ascent of dust and other light matters in opposition to the attraction of the whole mass of the earth conflicts with them, and their alleged result. They think a body inclines to a mountain, as corks float towards bungs and scattered fragments of wrecks to the hulls, in consequence of intercepted atmospheric pressure. 'So boats incline to intercepting ships, plummets to intercepting mountains, and nicely poised leaden balls and drops of water and mercury yield to each other's interception.'

To meet such objectors we would vary the experiment, by substituting for the plumb line and bob a small air-tight cis-

tern of glass, or with a glass cover, half filled with a limpid liquid and provided with a suitable float. Firmly fixed to the face of a mountain, free from external disturbances, and not limited as to time in its operations, the float should be found, sooner or later, to approach the mountain, or the liquid surface raised towards it as an inclined plane. The vessel might be spherical and the air exhausted. To diversify the experiment still more, even air or gas might be used in place of water, or other liquid.

It is however said, and justly, that it is of little consequence whether attraction be acknowledged or not as long as the phenomena ascribed to it are admitted, and of *their* reality there is not room for the shadow of a doubt. The difference is then more about the name than the thing, for the term has been adopted to denote a series of facts—not the principle or process by which they are brought about. It may possibly become modified or even give place to another.

A change of name would not, however, meet entirely the objections of those who think matter has *weight* irrespective of attraction. If, say they, it be not spirit, a handful of cork can under no circumstances balance a mountain of gold, because there is more matter in the latter than in the former; in other words, weight is not an incident but a quality. They would explain the mysterious influence by which distant bodies are said to be reciprocally pulling, or striving to pull, themselves together, as nothing more than the tendency to recover their *natural bases* in the masses from which they have been directly or indirectly sundered—that this tendency is their weight—that universal gravitation is the effect of universal disruption of the primordial nebula; and local gravitation (upon the spheres) of local displacement.

Large masses, they say, control smaller, because these are the offspring of the larger. A ripe apple drops from a tree, and what else could it do but return to its parent body! The matter in it was forced up from the ground, and upheld till its weight exceeded the supporting force. All bodies belong to those they react on; the fruit to the tree, the tree to the earth, the earth to the sun, and so on. And thus it is, that partial leads to general, and general to universal gravitation. In this view, gravitation is the contracting or converging opposed to the expanding or dispersing power.

The perturbations of the planets, and the tides, which so remarkably confirm the doctrine of attraction, have not yet been accounted for on any other principle.

But the properties of matter, how they exist, and even act in all cases, are incomprehensible. Manifest as are their effects they are themselves unrecognisable by any of the senses, so that whatever may be objected to attraction there is truly nothing more incredible in it than in qualities universally acknowledged. All substances are capable of compression as well as of dilatation, and it is admitted that in none are their constituent elements in actual *contact*. How then do they hold on at diverse distances? They appear to cling to each other with a tenacity that increases as the distances between them decrease, but the mystery is, how they resist separation when not joined at all: so that a stone whirled round in a sling, whose particles do not actually touch one another, is quite as embarrassing as attraction at greater distances. The difficulty of belief arises from the magnitudes of the spheres and the vast spaces between them; but what have these to do with a principle coexistent with matter? An attribute inherent in atoms cannot be lost in

masses or be drowned in space. If attraction exist in the smallest it exists in the largest masses, and is exerted over the greatest as over the smallest of distances.

We shall have occasion to recur to the subject.

CHAPTER IV.

FORCE: Analogies between mental, moral, and physical forces—Marvels of material force—It is the soul of creation, the light and life giving principle, ubiquitous, and yet arises out of matter—Its affinities material—We could not treat it as we do if it were a spiritual essence—No regular motion or form produced by it unless under the direction of mind—Admits, like matter, of indefinite division—Its material origin unpleasant to some minds—As the motive power of the universe, supposed by others to be in an especial manner in the hands of the Creator—The idea derogatory to Him—Human agency in the arts not more patent than that of the Creator in Nature.

WE are sensible of three distinct kinds of force—*mental*, *moral*, and *material*. We feel them working in us, upon us, and around us, while of their compass and fulness we have constant proof. Each has its own mission, and interferes not with the others. The principles of morals affect not mathematics, no amount of reasoning can neutralize inertia, and with the decalogue wheels and pinions have nothing to do. Still, they have striking analogies: each flows in opposite channels—in ethics through compulsion and persuasion, severity and kindness; in physics by driving and drawing, or pushing out and pulling in; and there are incorporeal attractions and repulsions, mental as well as chemical affinities. All are essentially expansive: The preacher, astronomer, and machinist alike go abroad for material to act on.

Embracing the whole range of physical and spiritual existence, these forces accord with the elements of our compound nature, and might therefore be supposed to harmonize in evolving the greatest amount of good. Such is the fact: as when our mechanisms are contrived by enlightened reason, and employed for the general welfare in unison with the dictates of morality.

But it is to material force that our attention is pledged, and of physical marvels it surely is among the greatest. Not while science is cultivated here, or the wonders of creation studied in yonder spheres; not in the past has there been revealed, nor in the everlasting future can there be disclosed, a subject more subtle and sublime, or one more essentially allied to infinite and eternal results.

Without force, what a blank had creation been! Neither varieties nor properties of matter, neither colors nor motions, not a voice nor a sound; nothing but eternal silence and blackness of darkness! It is the soul of creation. It germinates in plants, creeps in reptiles, runs in quadrupeds, flies in birds, and swims in fishes. It expands the acorn into the oak, reduces boulders to pebbles, and changes strata of rocks into beds of sand and clay. It erects our dwellings, reaps our fields, drives our carriages and mills. It built the heavens as it built the earth, and does all the work in them as it does it here. The spring of action in every phase of society, it is among the things with which we have most to do and yet think the least of.

Every thing else is changeable. Neither plants, animals, nor worlds are in all respects an hour the same, but force is now what it ever has been and ever will be. With it, as with the Creator, there is no variableness nor shadow of

turning. Is it permitted us to know what this strange thing is, which, like a shadow overcoming substance, is so palpable in its effects, and so evasive in itself? Which perishes not with the bodies it builds up, but passes into other forms as they melt away! Felt but not seen, what is its nature? Has it an existence independent of matter? Is it an effect or a substance?

Some might suspect the race of human progress nearly run if it could now be determined what this light and life giving principle, this beautifying, vivifying, and pleasure-diffusing essence, agent, or whatever else it should be named, really is. How, say they, can man advance for ever and take a step at once so great! What can elude him hereafter with accumulated knowledge and perceptive powers quickened! What prevent him from at length scaling the throne of the Highest and prying into the origin of matter itself! There need be no fear. Whatever success may reward his exertions in the rôle of the future, he can never remove the surroundings that enshroud final causes. The ultimate will always be beyond him, though he may be ever drawing nearer to it.

Force has been deemed immaterial from a persuasion of the impossibility of matter originating and perpetuating the activities of the universe. As an emanation of the Divine mind it is so far spiritual, but the same may be said of electricity, sound, motion, or anything else; and as for the ubiquity of force the same may be said of matter. It is universally extended, and therefore omnipresent.

There is the boundless expanse charged with rolling spheres, each crowded with minor forms and motions in unimaginable variety: If the force that has thus worked up

matter, and keeps working it up, arises not out of matter, there is nothing else to which to ascribe it but *spirit;* and to *it* there is the objection which philosophy, our instincts, and experiences oppose to any hypothesis of immaterial essences handling, or in anywise overcoming the inertia of matter. We should have to concede that individual beings are assigned to work individual organisms, or that spirit, like matter, exists in bulk.

Do the glorious forms and motions, then, which characterize the heavens and this orb of ours, arise from lumps of earth? The spheres are nothing more. Do winds, lightning, the powers of vegetation, the strength of the ox, spring of the tiger, flight of insects and birds, playfulness of the dog, and gambols of children, originate in crude matter! Yes. The fact at first glance seems impossible, but there is no ignoring it.

Force bears a similar relation to matter as mental power to mind, but its affinities are clearly physical, as exemplified in its habits and abodes, invocations that draw it forth, and in the yokings of it to machinery. We know nothing of it except as it is presented to us in material vehicles. It is that alone which renders it manageable, that enables us to vary its forms and modes of action, augment or lessen its intensity, transfer it from one object to another, call into play just enough to agitate the fringes of a feather or sufficient to lift a mountain from its base; collect it in boilers of one or one thousand horse power, make it portable in gunpowder, inclose it in soda fountains, and bottle it in champagne! We place it on constant duty in mantel clocks, and carry it in our pockets coiled up in watch-springs! And with what ease can we draw it through steam and gas

tubing, direct it where we wish, and make it do our bidding!

If it were a spiritual thing could we use it thus? But if spiritual should it not be intelligent? Is not all that is not matter, mind? But Force, we do know, is not mind, because wherever and whenever left to itself it is *incapable of results* —i. e. of any but conflicting and destructive results. Every proper motion in natural or artificial mechanisms ceases when interfered with, or the designing power no longer controls it. A rabid animal, and a locomotive carriage running off without the engineer, are alike insane, expending their reinless force on their own destruction. It is the same with mental power in the absence of its guide; ebullitions of anger resemble useless explosions of bombs, and ravings of passion the screechings of wasting steam.

No regular or useful form is or *can* be produced by unbridled force. Intelligence *must* be present. A rock never shapes itself into a. statue, the ores think not, water does not reason, nor is the air embued with affections. It was not till the spirit of God moved over chaos that creation assumed form and order, nor is it till the spirit of man acts on crude matter that the arts arise. We might as well look for resentment in timber and pity in stones, as suppose force of itself works matter into nature's forms of benevolence and beauty—as reasonably expect it to produce vases of cut-glass and finished instruments of steel.

If matter were originally capable of thought it would be so still. If it possessed the attribute as a whole, it must have it in its parts; if in a universe in a world, if in a world in a pebble; for thought, or the faculty of thought, can have no relation to bulk, nor be broken and ground up with material masses.

The identification of force with matter is also obvious in that it also is capable of indefinite division, and loses none of its virtue in reduced quantities. In truth, its operations in minute organisms are as surprising as in the movements of the largest masses. How the minikin bodies of insects contain enough to overcome the friction arising from the play of their organs, is a puzzle. It might, without observation, have been thought that the less animated beings became, the more they would approach, as regards motion, mollusca and zoophytic tribes; but the reverse is the fact, for the nimblest and most active, the wildest and most impetuous, are among the smallest. Is it not wonderful how a gnat extracts from a corpuscle of food sufficient power to work its wings for hours apparently without fatigue, and certainly without the appearance of effort. But flies are mastodons compared to living mechanisms, of which legions might find room in the stomach of a fly: every one provided with an apparatus for collecting food, another for its elaboration and evolving force from it, and with motive organs for its active employment. The economy with which force is excited and applied in these creatures is to me one of the greatest of natural and philosophical wonders. Moreover, it is doubtful if the smallest of animalcules can ever be discovered, any more than ultimate atoms.

As with matter, we may contemplate force from the flutterings of a microscopic moth's wing till it fills the heavens and is lost to mental and material vision in the depths of the infinite.

To many minds the idea that it springs from matter is an unpleasant one, because they think it excludes the Creator. It, however, does no such thing; for the more the subject is

examined, the stronger is the conviction that, in Nature as in Art, matter is always the *medium* and never the *director* of force—that it is mind which adapts the material to the power and brings out results. This undoubted fact is sufficient to disperse every doubt about the presence of the Creator in his works. Where they are He is, just as where artificial machinery is in action, man is sure to be close by.

If force *of itself* could evolve and sustain the existing varieties and harmonies of creation, matter might verily be said to be God—its own creator and controller—but there is no more evidence of it than that granite feels or beds of coal complain of pressure. Matter is the common instrument of mind—the house it dwells in, the book it writes on, the substance it works with. Without mind it is *void of application.* Our very instincts tell us that it is the agent of something underlying it—of mind; and consequently that every form and motion is the expression of thought.

As the MOTIVE-POWER OF THE UNIVERSE, Force is thought by some persons to be, in a more especial manner than anything else, retained in and wielded by the hands of the Creator. Instead of magnifying, this is derogatory to Him. It implies that some of his works are more difficult to manage than others—a thought superlatively earthly and infirm. They whose reverence rises with masses should find it decline with them. They should feel Him more fully present in a mountain than in a hillock, in a ton of limestone than in an ounce of chalk. They have to learn that one law suffices for the conservation of worlds as of the smallest things—that a galaxy of stars and a swarm of flies are developed as naturally as plants grow, and as inevitably as action induces reaction. They should know that magnitudes and

velocities are as nothing to Him, and that he pervades their fields and gardens as fully as any part of the heavens.

An earthly architect may find it expedient on particular occasions to handle the plumb-line, and the naval constructor the adze, but the works of the Great Builder require no such intervention at his hands. The spot is in the lens we look through. Would it not be irony to commend a mechanician for his chronometers keeping time when out of his sight! And what do they, who think to compliment the Creator for giving special attention to the main-spring and movements of the celestial horologues lest something should go wrong! Do they not treat Him, though unwittingly, as a bungling clock-maker!

We judge of our own efforts by a different standard, for it is justly held less creditable to elaborate matter directly with the hands, than by artificial instruments and inorganic forces. Of innumerable articles that minister to social enjoyment and refinement, there are comparatively few which are not produced by forming mechanisms, and that too when the artist's back is turned as well as when his eye is on them. His agency in some things is not more patent than that of the Creator.

As a general thing we know little more of human artificers than of the Author of Nature. We do not so much as hear of one in ten thousand of the fabricators of staple goods. Who they are, where they are, on this side of the planet or the opposite one, we are wholly ignorant, while of their existence we have the strongest of possible proofs in their works—stronger than that of their bodily presence. We might be mistaken in persons: they might or might not be the authors of the enumerated productions, but in the things

themselves we are as certain of the reality of the being and labors of their makers as of the most familiar facts. While they are invisible, their thoughts breathe in bellows, glow in furnaces, are reflected in mirrors; surprise us in applications of steam, electricity, and the telegraph; charm us in music, statuary, and painting; and excite our gratitude in endless gifts of utility and taste. So it is with the mind of the Creator: it is reason in man, instinct in animals; it shines in the sun, sings in the thrush, it is fragrance in flowers, transparency in crystals, tenacity in iron, ductility in gold, and beauty and harmony in everything.

The conclusion is, that matter is made capable of being formed into natural and artificial organisms. The Creator has reserved the production of the first to himself, while finite intelligences are ordained to preside over its conversion into the second. To which may be added that, as human supervision is indispensable to the continuance of artificial mechanisms, to start them afresh as their springs run down, and renew them when worn out, the perpetuity of natural ones depends on the Great Overseer—as certainly and as literally.

CHAPTER V.

Force or power one, as matter is one—Demonstration of its essence impossible—A time-piece—Matter originally a thin fluid, and why—Mobility of atoms—Motion an absolute property of matter—Molecular motion the source of all motion—Fluids naturally assume the spherical form and revolve—Form and motion of the primordial nebula—Theory of La Place—Why subdivision of celestial matter closed with moons—Form and motion of the spheres a corollary of the universal rotation—Orbital originally axial motions—The original nebula not 'a fiery fluid'—Miniature figure of the universe—Distribution of matter substantially the same now as when all was fluid—It may still be viewed as a fluid—Attraction of gravitation an extension of that of cohesion.

As force then is wholly material, of what does it consist? On what properties of matter depend? How is it evolved and how does it act? These, and other particulars, we shall have occasion to advert to as we proceed; and before doing so, it may as well be remarked that technical distinctions have been made between 'force' and 'power,' but as there is no essential difference, we shall use those terms synonymously. Natural and artificially excited forces are varieties of the same thing: that which moves a world is the same in its origin and essence as that which turns a wheel, shakes a leaf, or lifts an eyelid.

It will, of course, be understood that force is *one* in the same sense that matter is one: that as varieties of forms and substances are combinations of the same elements, so the

multiplied manifestations of force are different phases of the same thing: hence, when we speak of it in the plural it is to accommodate our ideas to the diversity of its demonstrations.

The further we go back towards the origin of matter the nearer we approach that of force. Let us therefore advert to the early operations of both. And let us remember, when speculating upon that which is infinite in its bearings and inscrutable in many of them, that demonstration is not always to be expected. It is no new remark that there will always be phenomena in the series of causes, incomprehensible to us and to intelligences who, like us, live only in time and space, and who feel and act by the impulse of limited senses and powers.

It is somewhat common to view the universe as a time-piece, perfect in design and execution, in the range and rates and softness of its movements. Its trains of wheel-work are constellations, worlds are wheels, planets pinions, and suns pivots on which they turn. No escapements are required to induce changes of motion, no compensating balances to regulate them, nor fusees to equalize the tension of the maintaining power. All this we perceive, for it is open to observation; but the chief thing, THE MAIN SPRING, is invisible.

Let us try to find out what it is, since it certainly is allied to all minor forces.

In contemplating the first unfoldings of creation the mind naturally adverts to the condition of the material. That it was an exceedingly thin vapor or *fluid*, with all the known properties of fluids, is uniformly conceded; and in confirmation is the fact, that all substances are reducible to this first form of matter.

It is inconceivable that the empyrean could have been originally charged with *liquid* matter, since no lighter substances could have been formed of it, or moved through it. Such could only have been produced by expansion, but there would have been no room for expansion. The same objection applies with greater force to an universal *solid*. There could have been no bodies less dense than itself, and no space for them to move in. Stars and planets, if formed at all, had been as securely fixed as inlaid figures in mosaic work. There could have been no motion. Several interesting topics for discussion here occur, but they all tend to one conclusion—that primordial matter was highly attenuated, in which condition only could its present distribution have been effected, and its diversified densities attained. Every liquid or concrete body formed out of *it*, left more room and a less resisting medium for all to move in.

Space then was charged with a thin nebula—the seminal fluid out of which the universe in all its glories has grown. As there was nothing else whence foreign influences could come, it necessarily contained within itself the germs of all forms and the elements of all forces.

When speaking in a former chapter on the properties of atoms, their *mobility* was omitted that it might be introduced here. They are incapable of rest. There is no possibility of depriving them of motion, whether locked up in solids or in less rigid prisons. They break down all substances, and keep entering others, and others, which they treat in like manner. They appear to move with increasing freedom, or through increasing ranges, as density diminishes, from metals to imponderable bodies.

Some philosophers have ascribed to them *life*, as Leuwen-

hoek, when he first beheld legions of animated organisms in a globule of water; and others when subsequent researches proved that hundreds of millions were contained in a single drop, moved in it with the varying velocities of fishes, and with abundant sea-room. They mistook these for ultimate atoms. Another revelation of the microscope seemed to strengthen the erroneous inference: when water charged with infusoria becomes evaporated, and the residua swept away by the wind as dry and impalpable dust, they revive by moisture into whatever regions they may have been borne. Leucippus, and others before him, taught the restless nature of atoms, and some deemed them the elements of life as well as motion.

Their mobility shows that motion is an absolute property of matter, and therefore imperishable, irrepressible. This truth lies at the foundation of physics. Instead of matter being innately inert, as many think, motion is its *natural condition.* Turn where we will, it is nowhere at rest, either in masses or in molecules. The spheres are moving in space, and our earth with them. Nothing is at rest within itself. Wood decays, metals rust, vegetables and animals die; every form and substance changes because their molecules can neither rest nor be retained within them. It is, therefore, to the mobility and momenta of atoms that all material phenomena—all forces and motions are ultimately referable. If they did not possess individually the attribute of motion, no collections of them could have it. As there were no motions anterior to them, the conclusion is irresistible that *it is movable atoms that make movable masses.*

It might seem impossible that the power of creation in all its intensities, here animating insects and yonder whirling

constellations through space, could proceed from the silent and imperceptible movements of molecules, but the closer we look into nature the clearer we perceive that in all things the great springs from the little—the largest from the least. The universe is a magnified molecule. Its phenomena arise from the attributes of atoms—a fundamental verity which solves many difficulties, and makes evident the fact that molecular motion is the ultimate source of all motion.

Take the atoms of gas that fill a balloon. They are constantly interchanging their places in it, and would continue to do so for ever if they could be kept within it. In the absence of external influences, were such a thing possible, they would gather themselves into a spherical mass, as does a globule of shot, rain, or dew, and their complicated movements within would give rise to a new and simple one without. As the mass could not remain at rest while every part was intensely excited, it would of necessity assume *some* motion, and that we know would be a revolving one. It would begin and continue to rotate. No other motion could be generated, because there would be no impulses or pressures to induce any other. The force of the revolving sphere would be directly as the mass; representing, as it would, the momenta of the atoms composing it. And the motions under the conditions named would be enduring as the qualities of matter that gave it birth.

Apply this to the great Primordial nebula, for its molecules acted precisely as they act in fluids now. From the same cause *it* began to rotate, and then Cosmical Power was revealed—the first conversion of internal motion resolved into an external one—an infinite amount of force manifested in the movement of an infinite amount of matter: for the

general movement of the heavens expresses the momenta of the atoms of the universe.

However multiplied interior actions may be, the universe as a whole must have a *common movement*, or none. One division cannot, in relation to the rest, stand still, lag behind, fly off or diverge from its place, without destroying all unity. The earth is full of motions, but they do not interfere with her general and uniform motion—so it is with the universal orb: Its rotation is, we believe, fundamental—the basis of all other movements—without which there could be none other.

In everything there is virtue in FORM, and we surmise that vastly more depends on the configuration and movement of matter as *one mass* than has been suspected. As perfect a whole as any of its parts, must not the universe have a definable outline or shape, one to which nothing amorphous can possibly belong? What is its figure? It can hardly be a cube, cylinder, or prism of any kind: indeed, we might as reasonably suppose it a three-sided figure as one bounded at all by straight lines. No one extending in one direction more than in another could have met the exigences of creation; and that the universe is a sphere may also be inferred from fluid matter naturally assuming that form—perhaps because its elements have it. Had atoms been bounded by plane surfaces, so, we may suppose, had worlds, drops of water, and soap bubbles.

The universe is spherical, then, because its molecules are, and it moves because they are incapable of rest. No other shaped mass could have been equally fitted to revolve, or to revolve uniformly, or to preserve its shape. In fact, any other was impossible, since angles or protruding parts would have to sweep over vacuities in space, whereas none such can

by any possibility exist. Moreover, motion cannot be eternally continued in straight lines. If it could, the celestial bodies would be dispersed, the swift-moving would leave the slow, intervening distances would for ever increase, there would be no bond of social grouping in systems, nor of phalanxes in constellations. Instead of a fellowship or commonwealth of orbs, everlasting isolation and estrangement would prevail. Only in circles can motion be continued for ever in the same direction.

We therefore conclude that the heavenly bodies are rotating spheres because the universe is a sphere and rotates.

If this common movement of the fluid universe be accepted the next query is: How came the mass divided into the countless orbs which now appear in the firmament? Processes akin to the formation of hail and rain, to the appearance of nuclei of crystals, or of germs of animal life in nutrient liquids, for the ether is the mother-fluid of the spheres, might be suggested, but they would not approach in pertinence and plausibility the beautiful one of La Place. His scheme of the condensation of nebular matter into suns and planets, it has been observed, suggests the only rational explanation of the phenomena observable in the sidereal heavens and in our own globe, according to the present state of the physical sciences; while its beautiful simplicity is in correspondence with the unity of design so manifest throughout the works of the Eternal.

The general process was necessarily one of *condensation*, but from what causes did this set in? We would say from gravitation, for we would rather give weight to atoms than make them *red hot*. But passing this for the present, successive portions of the nebula were cast off, as often as

the centrifugal exceeded the centripetal or gravitating force. Axial motion necessarily took place in each, just as it took place in the parent one—whether or not originating in the deviation from radial lines of the converging molecules, and thereby destroying the equilibrium of each mass—hence galaxies, constellations, systems, down to the smallest of individual orbs.

In this way we may suppose the monotony of the scene was broken up. The process accords with our experience of fluids, with a well known law of fluids, and with molecular action, which, as has been remarked, is most intense in gaseous matter.

The subdivision is carried no further than moons, but their number greatly varies. One planet has eight, another six, another four; our earth has but one, and some seem to have none. Why this arrest of the division of cosmical matter? Perhaps because masses much smaller would not contain matter sufficient to generate heat at their centres by compression, and maintain an interchange between internal and external materials, which appears to be essential to habitability. (See chapter on the Cause of Heat.)

The first movement of matter—that is of atoms in mass—was then the rotation of the universal mass. Now no subordinate motion could interfere with this: indeed, none such could arise, since all spring from it. Hence while the material of each system or sphere was separating, and subsequently turning on its axis, it retained its position in the parent mass, and kept, and keeps, moving on in the general sweep. The formation and movements of the spheres are therefore supposed to be a corollary of the universal movement. By no other imaginable process could they have been

produced, and that only while they were fluid. Had original matter been liquid or solid, it is impossible to conceive how they could have been separated from the parent mass, attained the places they occupy, or acquired their present movements.

According to these views, orbital movements, it will be perceived, are all derived from axial ones. They are axial motions developed in diminishing series. There is therefore no need for seeking out separate causes for their origin or their continuance. That which began them—universal rotation—perpetuates them.

As just hinted, we do not perceive the necessity, or philosophy, of charging space originally with a 'fiery fluid.' If atoms were naturally incandescent they would be so now; nothing could quench or neutralize their heat; but if not, whence came heat? and how? and for what purpose? If condensation could not begin till the fluid began to cool, nor continue but as the heat was got rid of, it was not only not wanted, but was a positive hindrance. Heat is the agent of expansion. It retards or prevents the conversion of fluids into solids. For what purpose then was it required? To diffuse the original nebula? Surely not, or it would be as much required by the more rarefied ether now. We should say that condensation was the effect of gravitation, and that heat was not manifested till evolved in suns and planets, nor wanted till then.

A glass globe charged with one, or more than one, permanent gas is perhaps the best miniature representative of the universe. As a whole the molecules, if made visible, would appear agitated and in confusion, while an analysis of their movements would show them circulating harmoniously

among themselves, according to some definite law. Space is a transparent vase in which everything is magnified into the other extreme: but dimensions of molecules, their distances apart, their ranges and velocities, affect not a principle, and we perceive nothing unphilosophical in supposing the same law that holds the elements of a permanent fluid in suspension, holds the spheres in their places—*the extreme expansion of molecular action.* The distances between them are no more wonderful than those between atoms in common substances. In both, distance is modified by magnitude and magnitude by distance.

Nor does it appear that the distribution of matter is essentially different from what it originally was. Admit the spheres to have been collected out of the areas their fluid material occupied, and equal amounts of matter are still contained within equal areas, though not equally diffused over those areas. Planets turn with suns, and moons with planets, within the same boundaries, and at the same average distances, as did the nebulous matter of which they are made; so that, were they again rendered fluid, they would refill those areas as they filled them before.

If we were not so accustomed to act the part of the fly in the temple, there would be little difficulty in still viewing the universe as a fluid, only not a homogeneous one. If the spheres are denser than their original material, is not the matter diffused as ether vastly more attenuated? It fills infinity, while they fall infinitely short of filling it. But the spheres themselves are far from being compact bodies; all that we know anything of are agitated with intestine forces; and as for the earth, there is nothing solid about her, nothing to bind the loose soil on her surface or hold her broken

strata together. To say nothing of oceans of sand and of water, or her aerial envelope, upward currents are unceasingly maintained by the central upheaving or earthquaking power, and they induce downward ones. It is true these movements are so exceedingly slow as to appear irreconcilable with conventional ideas of a fluid, but they are more incompatible with a perfectly solid body. But solid or not, in a comprehensive view, the boundless expanse is charged with only a coarser nebula than at the beginning—like dew in our atmosphere gathered into hail.

The elements of all bodies are held together by cohesive or attractive forces, according to their natures. So it is with the universe. The parent of all bodies cannot be less perfect in the structure, texture, and cohesion of its parts, than any that spring from it. As molecules in small masses are held at diverse distances apart, resist forces tending to derange them, and actually recover their position when the displacing power is withdrawn—the case of all the metals—so the spheres have their places and motions as definitely defined as molecules in an onion or an orange.

As the material of the spheres was collected out of their orbital areas, and equal amounts are still contained within equal areas, must not the mass of each sphere bear the same relation to the rest as when all formed one homogeneous fluid? And as with each sphere, so with every atom in it. The law of attraction of gravitation is, then, we may suppose, none other than that which pervaded the fluid universe. The present constitution of the mass has neither weakened the sympathy of one part or one atom for another, nor the bond that held them together.

Could this grand law have been discovered had not the mass been broken up into divers rigid parcels, so that the

influence on one might be compared with that on others? [But see further on, where a doubt of uniformity in the intensity of attraction of gravitation is thrown out.]

Let us repeat: Attraction of gravitation combines the material of creation in one mass. It is obvious that some principle of the kind is indispensable in the constitution of every body. There must be something pervading constituent ingredients to induce them to coalesce and oppose separation; hence we find them held together in every substance, fluid or solid, by an attractive force peculiar to each. So it necessarily was and is with the universal mass. The spheres are now its constituent elements, and attraction of gravitation in them is analogous to, and, as we believe, identical with attraction of cohesion in minor masses. It was no new bond introduced with the gathering of the primal nebula into stars, though it may have been modified in the process. If the water of an ocean were converted into small pellets of ice, the character of the mass as a fluid, and the mutual affinity of its elements, would be slightly but not essentially changed; neither has the conversion of the primal nebula into spheres destroyed the fluid character of the mass, or broken the bond that held its particles originally together. Dissolve the pellets, and things as regarded them would resume their former position; just so it would be with the spheres were they resolved into the parent fluid—attraction would resume its original form and power.

In thus assuming the suspension and movements of the spheres to be the extension of that principle whose other extreme is in cohesion, there is nothing implied inconsistent with acknowledged discoveries in astronomy; on the contrary, it provides for phases, or variations, in attraction of gravitation of which there have been prophetic indications.

May we not close this chapter by observing that groups of orbs are examples of variety in the constitution of masses, and that the spheres have nothing more to do with their suspension in the firmament than when their material was uniformly diffused through it? Integral portions of the rotating universe, they are borne in all their subsidiary whirls along with it; the pervading bond that holds them in their places—the law of whose intensity is ascertained—being really no more mysterious, than that which holds animal, vegetable, or mineral substances together.

I am aware it has been said, that attraction of cohesion cannot be the same as that of gravitation because it obeys different laws; but in truth nothing, or next to nothing, is known of them. Physical laws rest on the properties of matter; but while properties of atoms are invariable, those of masses change according to their condition and external influences. We are sure they differ in different sections of the heavens, and some may be, and probably are, developed there of which we know nothing. Let us not then insist on determining the infinite by the finite, by contending that every principle manifested here, is the same in its manifestations everywhere else. Because the intensity of attraction is directly as the masses and inversely as the squares of the distances in one system, it may not follow that it is so in all. May not that be the expression of a local variation of the universal law? Cohesion varies in diverse bodies; and as the solar system is to other systems what one substance is to another, we see nothing improbable in the hypothesis that the bond which holds spheres together may vary as much as that which links molecules to molecules, in vegetable or other bodies.

CHAPTER VI.

Things peculiar to the fluid universe—No mechanical forces—Circular motion, the parent and most perfect of all motions—Arrest of condensation in the spheres, and its cause—Inequality of resistance in the walls of the earth—One force generating an antagonistic one—Properties of matter merge into their opposites—The moon and her internal heat—What the proposed hypothesis of the arrest of condensation conflicts with.

Before taking leave of the fluid epoch of creation, which, we may suppose, closed with the gathering of nebular matter into condensing spheres, let us note some things peculiar to it, and the rather as the movements of the spheres, as already mentioned, have been contemplated in connexion with forces not revealed when they began their career.

Matter in the early epoch was inorganic; in the present one it grows, breathes, lives. Instead of a monotonous fluid it appears in variegated solids. The former universe was essentially frigid and dark, the present one is characterized by light and heat. The all-pervading power of one was manifested in contraction, that of the other is in expansion. Gravitation was paramount; it had nothing to contend with: now diversities of form and motion arise from its conflicts with a force that withstands it.

We are accustomed to think that there can be no motion where there is no resistance, but the doctrine, like some others, is inapplicable to the universal mass. It was not

one body moving through or against another, for nothing existed to oppose it. There was nothing outside of it. Moreover, it was not only free to move, but, a mass of restless elements, it was compelled to move. Nothing less than Almighty power could hold it back, and that only by changing its nature—by withdrawing mobility from its atoms and infusing quiescence in its stead.

As no foreign impulse was required to start the spheres into motion, so none is required to continue it. With common forces one body moves another, and they are impotent without fulcra; but had an abutment been necessary to the heavens, nothing less than another universe could have sufficed. There was no mechanical or dynamic force in the fluid universe, because there was no expansion. If worlds were now shrinking, fluids there could be none.

Requiring solid, liquid, and gaseous matter, mechanical force belongs to the concrete or present epoch. It was not possible for like motions as environ us to occur in the fluid one, or on spheres partially condensed, for they possessed no means to evolve force or employ it—no rigid base to act on, no levers, no fulcra, no fire, no fuel. Were we to credit those who make the elder and noblest orbs of our system—the outside ones, beginning with the magnificent Jupiter and his satellites—fluid or liquid masses, and their inhabitants "boneless, pulpy, watery creatures," the forces that give variety and beauty to this subordinate orb of ours are unknown there!

Circular motion, developed in the fluid universe, is the first form of motion, the parent of others. It is the most perfect and the grandest of all. It is the only universal one, for all others are local and exceedingly limited. It is uniform, others are unequal; continuous, others intermittent;

simple, others complex. It is peculiarly the motion of the heavens, and pre-eminently that of the arts. No masses like those of the spheres could have any other without being shattered to pieces.

Though we speak of the fluid epoch ending in the concrete one, we are not to suppose the orbs were simultaneously consolidated. There is no probability that they were. Judging from our own system and from the analogy of nature, the heavens in the order of their development resembled and still resemble a perennial forest—spheres and groups of spheres in the germ, and others in every degree of maturation. But passing this as a matter beyond our research, there is a point of decided interest to us, and one within the legitimate scope of inquiry, viz. the *Arrest or cessation of condensation* in the spheres. This was as indispensable as the beginning of it, for extreme solidity would render an orb as unfit for occupancy as a fluid one; neither vegetation nor animal life could be sustained upon it. Now as the cause of compression continued unabated, why have its effects ceased? Why has condensation abruptly stopped at diverse stages, and left the earth and her associate orbs in different and very moderate average densities? It is very obvious that a principle exists for arresting as well as for originating condensation. What is it?

We should say, it is the accumulation of heat at the centres of the orbs—*the natural effect of compression*, and one too well known to need illustration. Who has not kindled, or seen kindled, a match, by heat squeezed out of air in a syringe, and elicited from cold iron by hammering? The expansive effects of intense heat at the earth's centre are the urging of interior matter to the surface, and when the imper-

ceptible current is checked, volcanoes give vent to the excess of force, or earthquakes, more or less violent, are produced. The heterogeneous character of the strata can only resist a certain amount of expansive force, and whenever the superincumbent pressure has developed a little over that, further compression is prevented. It is thus that condensation produces in all cases a check for itself.

Perhaps it may be thought that the heat once driven to the centre would be dissipated by radiation, and could not easily be renewed? Such might be the case if the two processes of expansion and condensation were not perpetually going on, in consequence of one unceasingly preparing and presenting fresh material for the other. Central heat being thus the effect of pressure, is necessarily as enduring as its cause, and hence the certainty and efficiency of the check to further diminution of volume.

Two atoms cannot be forced into mathematical contact, because the resistance increases with the force. It is the same with the spheres: gravity cannot squeeze the earth into a smaller compass, because it generates a repelling power—force in another form—that equals its own. It is expansion against compression—heat versus gravity.

Of the absolute extremes of solidity and tenuity we know nothing. These terms serve to express conditions familiar to us, and are conformable to the constitution of bodies here; but to suppose matter approaches the limits of expansion and contraction on the earth would be preposterous. Terrestrial modifications constitute the golden mean for us only, and we cannot be too careful to avoid making them criteria for it elsewhere.

There is something else, besides the heterogeneous cha-

racter of the materials, which maintains an inequality of resistance to a central expanding force, and which would maintain it if they were of one consistence, viz. the centrifugal force arising from the velocity of the earth's rotation. This is greatest at the equator, where the effect of gravity is decidedly diminished by it; whereas it gradually decreases towards the poles, where it is nothing, and consequently leaves gravity unaffected by it. This alone renders uniformity of strength in the walls of the earth impossible, and guarantees the perpetuity of an interchange between internal and external matter. Another great purpose is accomplished, and may as well be noticed here. If the polar regions, as may reasonably be supposed, are not intended for human occupancy, there is less necessity for materials essential to the arts to be there pushed up from subterranean laboratories than anywhere else. And such would seem to be and to have been the case; for while the geographical extent of volcanic eruptions may be considered as demonstrating the universality of subterranean fires, they have abounded more in tropical and temperate than in other zones.

The principle which prevents gravity from squeezing the earth into a smaller volume is not only of universal application and importance of itself, but it opens one of nature's grandest secrets. It shows us how one force, or property of matter, generates an antagonistic one! How condensation, by eliciting heat, excites expansion! At first view this is very surprising. But reflection would suggest that if something of the kind did not occur, force and motion would of necessity cease—that if matter be swelled or pushed out it must be drawn in, or got back some way or other, because force cannot be indefinitely extended in any one direction—

that if expansion and contraction were not correlatives, if one did not exist to limit the other, the universe had long since been an impenetrable solid, or an infinitely dilated fluid. And that if motive bodies *could* expand or contract for ever, their force would be eternally diminishing—less to-day than yesterday, and still less to-morrow.

It has, of course, long been observed, that, turn where we will, we find one force met by another, but that opposing ones should have a common origin is not so apparent. We are not sure that the principle does not cause all properties of matter to merge into their opposites. The largest bodies are made up of the least, the softest of adamantine elements, light passes into darkness, heat into cold, height into depth, east into west, north into south, force acts in one direction and reacts on the opposite one. Death is a source of life, animals and vegetables die, but their material is ever rising into life again. Like a revolving scale, all things go on increasing one way, and return decreasing in another. Are not most of these facts due to the constitution and figure of the universe? We have before observed that if it were a boundless parallelogram, or polygon, the motions of the spheres would have been conformable, viz. in right lines; and we may now add, that permanency of outline and density in them would have been impossible. But being a sphere, however far worlds or groups of worlds may progress in space, they reach turning points, and go back again.

Just so it would seem to be with the properties of matter.

If there be orbs the pressure of whose masses is insufficient to liquify concrete matter, and thereby keep up an interchange of internal and external material, they must diminish in volume as they increase in density. Such solid,

cold, and passive masses, if such there are, must necessarily be very small. There may be ice, but no deep basins of water, where there is no internal heat.

That our moon has been the theatre of active volcanoes, all observers admit; and it is difficult to conceive how the cause, so essential and beneficial to vegetable and animal life, should have ceased to maintain them, if ceased it has. They probably never belched out lava and flame so violently as Etna and Vesuvius, because of the greatly less pressure. And if it were even established that some, or most of them, were now inactive, it would not prove the non-existence of others. Those on the earth change their sites; and from the miscellaneous character of her materials, they never can be permanently located through long periods of time. Though an exchange of material might take place without volcanic eruption, by some parts being slowly elevated and corresponding ones depressed, as is now the case with parts of the earth, yet the entire absence of volcanoes on our satellite would be, we think, as strong an indication of the absence of life and vegetation as anything yet suggested.

The inequalities of her surface, the very numerous mountains, with intervening valleys and extensive level regions, which mark the side presented to the earth, imply a central upheaving power; while volcanic combustion proclaims the presence of an atmosphere, whether too rarefied or limited in height or not, to be detected; but the opening of the era that is to mark the discovery of transmundane organisms we presume cannot be distant.

With the offered explanation of the arrest of condensation and permanency of volume of the spheres, all relative phenomena will, we think, be found to accord. It is, however,

in conflict with the received doctrine that the primary matter of the planets was 'a heated fluid,' that 'they contracted by *cooling*,' that 'their original high temperature is proved by the earth's store of internal heat,' and 'which heat is the residuum of that which in the beginning kept her materials in a wild and furious state of ebullition.'

Nor does the hypothesis exclude fossil remains from primitive rocks. But see further in Chapter VIII.

CHAPTER VII.

Forces developed upon the spheres—Terrestrial forces and their functions—Masses *in force*—One body moves another by impinging against it—By change of volume—Examples—Force not governed by mass—How small bodies overcome greater—*Force is expanding matter*—Primary force invariably a gas, and why—Different degrees of tenuity in motive fluids—Forces from bodies not aeriform are secondary.

THE present epoch of creation is distinguished by phenomena developed *upon* the spheres, as the previous one was by their formation and the establishment of their masses and movements. It is, therefore, in connexion with concrete matter that inquiries into force should be pursued, and with a principle that was not revealed till matter became concrete.

There is no need to go into distant regions to prosecute the task; at all events, not beyond the solar system, which is for us a special school. Leaving, then, the great moving masses in space, let us confine ourselves to it, and especially to the orb we inhabit. Every planet has something in its location and constitution which modifies its forces: this of ours is remarkable for its medium conditions, and consequently for medium developments. Still, its forces may be as numerous and diversified as any on neighboring orbs, and in all probability are so.

Terrestrial forces have been divided into *chemical*, *mecha-*

nical, and *vital*. The province of the first is to break down and build up bodies; that of the second to impart motion to bodies; and the third, a combination of the first and second, is dedicated to the highest applications of matter in living bodies. The classification is not so definite as it appears, nor is it strictly correct, since it does not discriminate between solar forces in operation here, and those of strictly mundane origin. It is, however, useful, as serving to discriminate between wide departments of philosophy.

What is Force, or of what does it consist? Let a person who has given no special attention to the subject, and is free from all influences of the schools upon it, exercise his own judgment and endeavor to discover what it is. He might say to himself: If it be not a direct emanation from the Godhead, it must proceed from matter. If it be an innate quality it should appear in all conditions of matter; and as it does not so appear, it must be an effect depending on contingencies. Further reflection would suggest as confirmatory of this conclusion, the fact of the same masses being *in force* under some circumstances, and *not in force* under others.

Convinced, then, that matter alone moves matter, he wastes no more thought in looking beyond it. He sees that bodies do not change their positions or places of themselves: he is sure of that, for every object familiar to him is not only indisposed to move, but actually resists displacement by its inertia. Fields of grain only wave while wind sweeps over them; the cart stands still till the horse drags it away; not an article in his dwelling, or out of it, stirs till something comes to disturb it. He is therefore safe in concluding that when one body is moved from a state of rest, it is effected

by some *other body in motion impinging directly or indirectly upon it.*

Hence, instead of the indefinite and somewhat abstract word 'force,' he will often prefer the plain and expressive term, 'motive mass,' or 'motive body,' since force is always conveyed in one, or rather is nothing but one.

Turning to any body at rest, for an example, he asks: By what means can it become a motive one? Aware of the direct bearing of the question, he determines to take nothing for granted, but to solve the problem, if possible, in connexion with every-day facts.

That which is everywhere present requires no going abroad to seek. Masons are at work in his yard, and he asks himself, How, for example, can a brick in yon pile, or a grape in one of those bunches, impart motion to its fellows? He reasons thus: To do that, some change must clearly first take place in it, or it will remain still and helpless as the rest; it must be a material and palpable change, for without that, were it embued with speech and faith, it could not induce its neighbors to move at its command. Man cannot do so much, nor the modern 'spirits,' who are said to be doing greater things in select 'circles.' The change must therefore be one of consistence, form, dimensions, or of some other physical trait. Which can it be? Perhaps the motion may suggest. There are but two directions in which a body in force can move others—*from* it and *towards* it. The change must therefore be conformable to, and capable of inducing, one or both of these. What, then, can it be, but *change of volume?* By no conceivable mode can a motive body cause objects in contact with it to move further off, than by thrusting out portions of itself and *push-*

ing them off; nor, on the other hand, cause them to draw nearer, save by drawing in portions of itself.

He now is ready to conclude that it is the shrinking or swelling of a mass that causes it to move other masses; but not to be precipitate, he reflects again and compares his reflections with common operations and results. His cogitations are prolonged; but the more he studies and compares, the stronger becomes his conviction that no inorganic mass can induce motion *while its bulk remains unchanged.* This, he therefore considers a decided step taken in the right direction.

Further observation and reflection lead him to suspect that force, strictly so considered, must arise from the swelling action, and that shrinking is negative in its relation to force; not moving but simply making room for bodies to move in. If a brick shrink, those resting upon it descend by their gravity as it shrinks, but this is not what he understands by force; he thinks it is not a passive creeping inwards, but an active pushing outwards. If the water of a steam engine only shrank, its motion would be as much confined to the boiler as a shrivelled apple thrown in. It could move nothing outside without *coming out:* so a bullet could not leave the gun if the powder did not swell to fill the barrel: by shrinking it would cling to the breech and never reach the muzzle.

Again: the space through which a body can be moved by the shrinking of a solid or a liquid is insignificant, and wholly insufficient to meet the requirements of nature or art. A cup full of water could not by contraction impart a perceptible amount of motion, while swelled into steam it might suffice to fill a room, and burst the walls asunder.

The action of a shrinking mass is confined within it, a swelling one extends into *new space*, and as he thinks the essence of force lies in that, he suspects all mechanical power must arise from expansion and subside in contraction; the former being primary or positive, and the latter negative force.

How does this agree with observation and facts? Expansion he finds pre-eminent among the attributes of matter, and without definable limits, while the diverse conditions in which innumerable substances appear—solid, liquid, or aeriform—are so many expressions of it. As contraction was necessarily the prime movement of the fluid creation, he perceives that expansion must of necessity be that of a concrete one. Force implies something aggressive, and that is what expansion essentially is. It is a going forth, in the swelling of bodies, protrusion of parts of bodies, and in an infinity of phases of vegetable and animal life.

He looks abroad and begins to think nature is a perpetual exhibition of expansive force, and that it takes the lead in *all* motions. It throws *out* the legs of the racer, while contraction simply gathers them *in*. Without it how could animals move to seek food, or stretch forth organs to seize it? All things grow by expansion. It bursts the seed, sends forth roots, shoots up stems and swells them into boles, throws out branches, blossoms, and fruit. The chick breaks the egg, its down swells into pinions, the infant dilates into a man. An object is in your way, and you raise your hands to remove it; it is out of your reach when you take a stick and send your force through it. It is the same with fluid motors; they have no special organs, but are all arms and hands, every part being ready to rush hither and thither,

and either directly or through intermediate agents. All this is expansion. The principle is vastly diversified. The actions of levers, wheels, pinions, ropes, and pulleys, are its emanations.

In contraction there is no outlay of material; a proof that the motion is negative, for no motive mass gives out positive force without giving out a corresponding portion of itself. Whatever influences the spheres may have on one another, there are no bodies here that can send forth attractive or repelling virtue without expending their substance with it.

But that primary force is expanding matter, is evinced in this, that only by expansion can small masses overcome large ones, which, if they did not do, nature had long since stood still? Do you ask, Is not force governed by mass? There could be no hesitation in answering in the affirmative if matter were as it once was, i.e. in one and the same condition. But, instead of that, it is divided into countless forms and substances, every one differing in its relations to force, so that equal masses do *not* give out equal amounts of force. They are not in the same condition to give it out.

Look where we will, we find small bodies overcoming greater. A slight mule draws a ton of building stone; a handful of powder shakes a mountain; a few gallons of water serve to drive ships on their courses and carriages on land. What, in fact, could have been the condition of things, if to move one body a heavier had first to be moved? Food is the motive material of living bodies; but not one could have crawled, or leaped, or run, except while gorged with a mass of aliment greater than itself.

[That force is ultimately referable to mass is obvious enough. Its elements abound equally in all matter—in iron, clay, and granite—but as those substances are not so readily put into a condition of force as others—not so readily expanded—they are not, under the constitution of terrestrial matter, adapted for motive materials.]

This virtual concentration of force in some bodies more than in others, is a *sine quâ non* in art as in nature. Human progress depends no little upon it, and hence provision has been made for extending the principle beyond the limits to which nature has limited herself. She does not compress into portable parcels forces equal to those of some artificial compounds, because she does not need them; but she has furnished us with the means of intensifying and multiplying them.

The solution, then, of the beautiful and inexpressibly important problem of small bodies overcoming greater, is in, and only in, *expansion*. Motive matter has no power till it is in a condition of force, and that condition is *expansion;* in fine, *Force is expanding matter.*

Whenever we excite force where natural motors are inapplicable or not at hand, the process, however varied, is essentially one of expansion.

But as expansion is unlimited, to what extent is it necessary to be carried to convert an inert into a motive mass? The inquirer thinks he is safe in assuming that primary force is *invariably a gas*, whether its presence be detected or not, or its action obvious or incomprehensible. He is willing to go further and accept the proposition—The more subtle the fluid the greater the power. If force is evolved in the dissolution and swelling of bodies, should not its intensity keep

pace with the swelling? And is not this sanctioned by the imponderable fluids, so called, which surprise us by their perfect and instantaneous results, and unaccompanied, as they are, by the noisy and gross attendants on vulgar forces.

'High steam' is more powerful than 'low steam,' simply because its material is more expanded—swelled into a larger bulk.

It must needs be that attenuated matter should be the vehicle to convey force over the earth's surface, and into her innermost recesses, to thread every crevice, commune with every substance, and circulate through the bodies of insects as of mastodons. Such a vehicle or agent must neither be lumpish nor subject to be held down by gravitation. It must be surpassingly flexile and agile, with freedom and facility to move everywhere, and with a constitution to permeate everything.

Suppose showers of coarse concrete the agents of force—wind rough and heavy as sand or gravel! What a scene of confusion external nature would present; people out of doors running to and fro, protected with pillows and mattresses! But as things are, forces the most energetic are playing around us, and *within* us, in matter so comminuted that we are in general actually insensible of its workings.

Varieties in animal constitutions may be supposed to depend more or less on the tenuity or subtlety of their internal forces. Of *degrees* of motive attenuation little or nothing is known, as the subject, we believe, has not yet excited attention; but that there is an ascending and descending scale we have no doubt. We can hardly suppose motive elements in the heaviest and comparatively sluggish

creatures to be as refined as in the nimblest of insects and most vivacious of animalcules. There appears no necessity for it, and nature does not unnecessarily elaborate. We infer that the comminution and distillation of motive matter in the slow-moving monsters of the earth and seas, may be less perfect than in the liveliest of nature's epitomes, and consequently less proportions of force extracted from it. In no case do we suppose the fluid attenuated into ultimate atoms. There may, therefore, be as great disparities in the magnitude of its constituent particles as between billiard balls and grains of dust.

But is not power obtained from moving matter that is *not* aeriform? Yes; from both solids and liquids, and hence the distinction between original and derivative force. The former emanates directly from motive gas, the latter indirectly. [Tide mills may be an exception.]

Power from steam and explosive engines is primary; so is that from electro-magnetism and other forms of electricity, the motive elements being evolved directly from liquids and solids, and directly applied. Water-power is not an original motor, as the liquid is first raised in vapor before it falls in rain and forms currents and cascades. Wind-power is like it. Put in motion from without, it partakes more of the character of an agent than a generator of force. Like water, it remains in its nature and properties unchanged. The muscular power of animals is primary to them; but secondary to us. We obtain it from moving solids—their limbs and bodies.

A ball shot from a rifle is a body in force; but its force is not its own. It performs what, in other circumstances, levers, shafts, belts, and drums perform. It conveys force to

a distance or place which the motive body cannot reach. Secondary forces do not affect the nature and quality of their vehicles; the ball is not altered in its flight, water and wind are not changed. Primary forces, on the contrary, are the result of radical changes in the constitution of motive bodies, as already stated.

CHAPTER VIII.

Expansion—Not obvious what it is—Receding molecules—Apparent expansion—Repulsion—Substance given to heat—Air in a bladder—Molecular spaces—Motion best explains expansion—Equivalent to increase of matter—The gyroscope—Motion, equipoise or substitute for weight—The secret of small masses overcoming greater. Heat, the cause of expansion, *is* Force—Its influence and effects—Wind-power—The earth as an air engine—Water-power also due to heat—Daily bending of Bunker Hill Monument—Effect of solar heat on the earth's crust—Internal heat of planets indispensable—Earthquakes and volcanoes.—Relation of heat to force perceived of old—Why so much matter in suns—Functions of suns—More than half of each planet illumined at the same time.

ADMITTING force to be expanding matter, what is it that causes matter to expand? Before attempting to answer, let us endeavor to ascertain what expansion is. Of the essential properties of matter, the following are usually named: Extension, figure, divisibility, impenetrability, dilatability, compressibility, porosity, mobility, inertia, attraction and repulsion; also elasticity, rigidity, &c. Mobility and weight are considered contingent properties. It would be greatly more satisfactory if the distinction between the properties of atoms and those of masses, or aggregations of atoms, were defined. The former are permanent, the latter contingent.

None of these phenomena are more obvious than dilatability, and none seem more difficult of explanation. We daily

witness bodies growing larger, but it is by accumulating fresh material; whereas expansion is understood to imply enlargement without additional matter; and that, too, whether the mass be doubled or trebled, or, as in some cases, swelled hundreds of times.

The principle of expansion is, however, the same, whether the swelling be imperceptible or palpable. There are two general phases of molecular action, and one is simply an extension of the other, as, indeed, it ought to be, if force is a unit. The first, common to matter in all conditions, is confined to the interior of bodies, and neither affects their position, outlines, nor qualities. It is going on in this hand, paper, and pen; in these chairs and tables, but it disturbs them not. Its presence is not sensible, unless when it is attended with a slight shrinking or swelling of a body, and is, therefore, of little application in the arts. Its action is internal. The second is when the action swells the mass to bursting, and destroys both its form and substance, as when solids or liquids dilate into gases. Then it is that internal becomes external force, and inert are changed into motive bodies.

Dilatability and compressibility, it is said, can only be accounted for by the molecular constitution of matter, according to which '*molecules are held apart by repulsion—at sensible distances they are attracted towards one another—within insensible distances there are alternations of attraction and repulsion—and at the nearest distances they do not touch, as an irresistible repelling force prevents actual contact.*'

This does not make one point much clearer. Can a solid, liquid, or gaseous body dilate without leaving hollow

spaces within it? Does a diminution of density imply an increase of porosity? In many cases we know that apparent expansion is caused by the intrusion of external matter, as when a drop of water is swelled into a sphere three or four inches over: but atoms are deemed absolute solids, impenetrable, and unchangeable in dimensions, and therefore incapable of being enlarged after the manner of soap bubbles.

Admitting, what we suppose cannot be controverted, that expansion is the result of molecules receding from one another, is 'repulsion,' which forces and holds them apart, an abstract power requiring no material agent, or is it represented by matter filling the widening spaces? The answer is in the hypothesis that assigns 'atmospheres' to molecules, and fills the spaces with the same substance—the imponderable vehicle of heat. The explanation is: the inclosed atoms attract one another while their envelopes repel each other—between the molecules of matter there is attraction, between the atoms of heat repulsion, and between heat and matter attraction.

The hypothesis serves to account for several phenomena, and is not wanting in analogy and probability; still it leaves some things in doubt. If ultimate atoms are surrounded, like planets, each with its atmosphere, must it not be larger than a part or particle of its etherial envelope or shell? Could it in that case be an ultimate atom? Then a distinction is made between matter and heat, yet the latter is held to constitute an 'atmosphere,' and must therefore be held as material as the molecule it covers.

The giving substance to heat *seems* to be supported by facts.

When steam boilers filled, or partly filled, with water, are

embedded in intense fires, the liquid is kept some distance from their red-hot sides by a highly attenuated and subtle fluid. In Perkins' Generators this was very observable, and what is remarkable, it refused to issue through a $\frac{1}{4}$-inch hole. It neither escaped itself nor suffered the liquid within to escape, till the temperature was reduced to little above that of ordinary boiling caldrons, when the issue became most violent. In some peculiarly formed boilers the phenomenon was formerly often observed, and led to a change in their construction. The same thing in another form is seen in drops of water rolling over a highly heated platina plate. Instead of instantly evaporating, an atmospheric envelope prevents them from coming in contact with the heated surface.

If the interposing stratum in these cases was caloric, or an imponderable agent of heat, whence did it arise? Had it any relationship to the metal or the liquid, or either? In the last example, was it not upon the platina dish and not on the aqueous globule, at least not in the first instance? The question, however, is not material to our present inquiries.

A kindred phenomenon may be noticed daily, especially in hot weather. If one or both hands be immersed in a basin of cold water, and held a few moments perfectly still, or rested on the bottom, the sensation of cold will be diminished if not wholly vanish. This effect is due to an *aurum* enveloping the hand and effectually interposing between it and the liquid. By the slightest movement of a finger its continuity is broken, and the flowing in of the frigid liquid instantly felt. Of course the same thing occurs with the whole body in a bath—in hot baths too, whether of air or water. In all, the stratum appears to be remarkable for its non-conducting power.

A close bladder half filled with air becomes quite filled when warm. What is it that the moderate heat does to the atoms to make them require more room? Does it burst their envelopes into spherules and cause them to whirl round, like planets, in widening orbits? Unless it does something like this, atomic atmospheres help little to solve the enigma of expansion. One thing only seems clear—that the heat excites the atoms from comparative inertness into intense activity, and compels them to extend their motions with every the slightest conceivable increment. This fact is indisputable, and of course is confirmed by reversing the process. As the bladder is withdrawn from the front of the fire the internal commotion dies out, and the membranous sac collapses again. Here is no tangible or other indication of any foreign substance, ponderable or imponderable, having entered and left.

May it not be said, as heat is the expanding, and gravitation the compressing power of creation, if one is a substance, why not the other? To this it may be replied, by asking: If force is not material what need of molecular spaces? But that is easily answered, for, were it not for them and the capacity for *gradual* enlargement, there could be nothing like what is understood by expansion—all enlargements would be violent explosions, and condensations sudden collapsions.

But if heat were material the difficulty of solution is not lessened. A fire is kindled under a boiler; what forces the heat into the pores of the metal; or does the latter have an appetite for it and drink it up as dry sand absorbs water? Admit all this, how does it enlarge molecular spaces? Would not resistance to enlargement drive it out, unless it acquired more energy within than without?

Under all circumstances MOTION accounts best for expansion. A stone whirled rapidly in a sling is efficient as a continuous ring to resist external pressures: so every excited atom of the multiplied myriads within the bladder acts efficiently as a ring. They are incomparably harder than the stone, the velocity of their movements as much greater, and then the most essential of remaining properties is not wanting; for, as if they had weight and were under centrifugal influence, *they recede from their centres of motion.* This is evident to sense by their swelling the bladder to its utmost tension, and, if the heat be increased, bursting its sides asunder:—a phenomenon more strikingly exhibited in explosions of steam boilers.

The divergence of molecules by heat is seen when the point of a heated rod is placed against the underside of a metallic plate over which a film of oil or other liquid is spread; also by the ascent of a drop of oil suspended perpendicularly over a flame from the end of a wire. Currents of air in front of a fire become visible when reflected by the sun upon the floor or against the wall. Increased velocities of the particles are then observable.

According to this hypothesis, atoms do not necessarily require envelopes, nor their intervening spaces any special material to occupy them. As expansions are mostly momentary, the spaces are only momentarily void. But speculations on the ultimate can only end in metaphysical conclusions. On this subject they are, however, allowable—perhaps more so than on most others, for the grandest of secrets—that of FORCE—is concealed in expansion.

It will of course be perceived, that if motion explains expansion, we know not by what process heat produces

motion. As we cannot tell how heat is excited by friction in atoms, it is not strange that we know not how it acts upon them when excited—what it does to them to throw them into commotion.

We have said on a former page, that the principle by which a small body overcomes a great one, arises from expansion. But does not this appear insufficient to account for the phenomenon? Dilating a mass adds nothing to it, no more than contraction takes anything away. The disproportion between two unequal masses is therefore not affected by one process or the other. The presence of something else must be suspected—something *equivalent to an increase of matter*, in order to enable the small one to turn the scale in its favor. Such is the fact. There *is* something, without which one body could never disturb a large one, viz. VELOCITY—one of the ultimate causes in the series of material attributes, for which there is no explanation. Force is not determined by the amount of matter in a moving body, but by the amount and its velocity; so that it is only by means of the latter that equal forces may be obtained from unequal masses, and unlimited force from limited masses. Thus we find a pound weight moving 2000 times faster than a ton has a force equal to that of the slow moving ton, and if the velocity were a hundred times greater, the force of the pound would equal that of a hundred tons.

As force is motion, and measured by the weight it raises (all resistance being reducible to weight), motion is equivalent to weight. The fact is illustrated by that interesting mechanical toy known as the rotoscope or gyroscope. As long as the velocity given to the whirling disc equals the tendency of the rotating ring to fall, the latter continues to

revolve on a pivot at its periphery, but as the velocity diminishes it declines from a horizontal plane and falls to the ground. The instrument in all its forms may be resolved into a steelyard in which, instead of two unequal weights being balanced by moving the small one further from the centre of suspension than the other, unequal velocities evolve the same result. We produce by mechanical force its equivalent in heat, and *vice versâ;* so in the gyroscope motion is resolved into weight, and weight into motion. The instrument does not neutralize the gravity of an isolated body, but it maintains in equilibrio unequally balanced parts of the same body. It might be constructed to determine in weight the equivalent of all motions.

Here we perceive, inexplicable as the phenomenon is, that motion is an equipoise or substitute for weight, and that expansion is analogous to velocity in moving masses. Explosive compounds have great force because of the instantaneous and extreme swiftness given to the dispersing particles. On the other hand, while from the same cause steam is animating our factories, that which ascends daily from the earth's waters, a quantity incalculably vast, is insufficient to impart motion to the minutest mechanism, because of the slow process of evaporation.*

The secret of small bodies overcoming greater, is therefore due to the greater velocities given them, for no small body can move a greater except by moving faster than the greater. On this wonderful principle the constitution of planetary creation at least is based; for without it no

* It may very well be that mechanical force is realized from ascending vapors in some of the spheres: that feature is, we may suppose, as much diversified as every other.

body in nature or art could have been moved except by a greater.

To extend the idea: Does motion act in any degree as an equipoise in the balancing of the spheres? Are inequalities of masses met by unequal velocities, and *vice versâ?* Does velocity in them increase as mass diminishes? It would seem so. The planets have more motion than the sun, since, while keeping up with him in his progress through space, they keep whirling round him, somewhat like small animals running round a traveller's carriage. Then moons, the smallest subdivision of cosmical matter, travel over more space than the planets, since they roll round them as they roll round the sun.

To return to expansion: We know that it is related to *heat*, as an effect to a cause; for whenever the circumstances attending the dilatation and compression of bodies are observed, it is found that change of volume is invariably accompanied with change of temperature—that all bodies swell with an increase and shrink with a decrease of heat. As therefore force arises from expansion, and as expansion is the effect of heat, the dictum is correct that 'heat *is* force.'

To heat is to be ascribed the difference between the living or occupied universe and the dead or untenanted one. Cold, unmitigated cold, accompanied the elaboration of the primordial nebula, whereas cheerful, inspiring heat permeates, as the glorious agent of expansion, the concrete spheres. As the proximate cause of force it is present in the feeblest as in the mightiest of movements, and its greatest effects are produced without noise or ostentation.

As to the finger of the Deity, to the slightest touches of

heat *all* things respond. Increments impalpable to sense awaken into life myriads of organisms, and where solar heat is most glowing, the most vigorous and diversified of forces are playing. In the tropics the dilatation of vegetables is so rapid as to be visible—the polar circles are comparatively silent and uninhabited wastes. Heat is the universal quickener—in other words the universal dilator.

How exceedingly slight changes of temperature affect the organization of bodies; turning the same substances into solids, liquids, and thinner forms! In the hatching of eggs into life, let there be a deficiency of one or two degrees of heat and they remain destitute of vitality as pebbles.

Kirby, speaking of the parallelism between plants and animals in hybernation, observes that in extra-tropical countries, or a great proportion of them, as the year declines and the amount of heat received from its great fountain is diminished by the shortening of the days, the deciduous trees and shrubs cast their leaves, plants of every description cease more or less to grow, and all vegetable nature seems to become torpid. At the same period, and under the influence of the same cause (decrease of caloric), several of the higher animals, all the reptiles, as well as nearly the whole world of insects, retire from the exercise of their wonted instincts, concealing themselves—some under the earth, and others under bark, under stones, in crevices, moss, and similar hiding-places, where they sleep till a more genial temperature whispers to them, *Awake!* This effect, in both plants and animals, seems to spring from the same physical cause—the periodical lowering of the temperature, so that heat appears to be the plectrum, and the organization of the animal the strings it touches.

Wind-power arises from the expansion of the air by heat. The earth is a perpetual motive air-engine. One-half of its fluid reservoir is constantly being dilated by the sun, while the other half, turned from him, is cooling and contracting. Local currents are produced by electric discharges, besides which there are other subordinate causes of atmospheric disturbance; but all are referable, mediately or immediately, to heat. The contrast maintained between equatorial and polar temperature is a permanent source of wind. Expansion of the *same matter* cannot be perpetual, hence the earth is ever turning *to* and *from* the sun, that the matter dilated during the day may have time to cool and collapse in the night, and so be prepared for expansion again in the morning.

Let us take a lesson here. The scientific world was recently on the *qui vive* about a motive air-engine, which, it was alleged, employed 80 or 90 per cent. of the heat over and over again, and would use the whole over when the mechanism was perfected! A prime mover that when once started, would cost nothing, or next to nothing, to keep it going! Its admirers did not perceive, and many do not yet perceive, that its energy was weakened in the exact ratio of its alleged saving of heat, and that if the whole could have been returned as alleged, it would have stood still. In the world's air-engine nothing of the kind is attempted. The heated fluid is invariably turned away to cool and condense before it is brought to the furnace again, and for the obvious reason that power would cease if contraction ceased. Were the entire atmosphere uniformly heated, and it would be if it gave out no heat, there could be no motion from it. The secret of all nature's forces is in the prevention of equili-

brium. Hence the perpetuation of wind-power is secured by the provision for keeping one part of the atmosphere at a maximum and the other parts at a minimum temperature. The atmosphere has a dash of water in it—a hint to engineers.

The earth's water-power is also the result of expansion. The sun rarefies the liquid. It ascends in invisible molecules without ceasing, and descends at intervals in globules faster than the ground can absorb it, forming for itself channels, here in trickling brooks and placid streams, and yonder rolling in volumes that sweep aside every barrier. The force of water is secondary, being derived from contracted matter; but its origin, as shown, is in expansion. If the ascent of aqueous vapor could be employed as a force, it would be a primary one. It, of course, equals that of the descending liquid; but the fluid is so diffused, its rise so mild and insensible, as to be inapplicable for mechanical operations in the arts; and yet what tempestuous, terrible, and overwhelming movements arise from it!

Here, again, we perceive that expansion could not be kept up without contraction. The ocean had long ago been dried up if cool nights had not succeeded warm days. In fine, if contraction did not succeed expansion there could be neither vegetation nor life. The tropics and temperate zones, instead of being alive with swarming activities, would be as silent and desert as polar circles of ice.

We have not the means of accurately measuring the effects of the solar heat on the earth at large every twenty-four hours; but we are sure the consequent expansion and contraction must be very great. It is not simply vegetation that shoots up to salute the rising sun, but rocks and moun-

tains acknowledge his presence. The Alps and the Andes raise their heads higher, and, like certain plants, move to and fro with him. This fact was brought out in relief by the experiments with long pendulums for proving the rotation of the earth, after Foucault's method. The perpendicularity of tall columns is being constantly affected by partial exposure to the heat of the sun. In the morning the Bunker Hill monument is inclined to the west; at noon, to the north-west. In the progress of the afternoon it sweeps over twice the movement of the morning, describing in the twelve hours of observation an arc of an ellipse. During the night it sets back to the centre, and before seven in the morning has already moved westward. Its sides do not face the cardinal points. The heat of the sun is supposed to penetrate but to a moderate depth, because of the prompt movements of the shaft when a shower of rain falls upon the more highly heated sides, as also from the ready changes of inclinations as the day advances. . There is, in truth, nothing here at rest. Our temples, obelisks, and chimneys, are, from changes of temperature, moving day and night.

Here, then, is a force working in the profoundest silence, so imperceptible in its movements as to awaken no suspicion of its presence, and so potent that nothing can resist it. Had this effect of heat on tall shafts not been known, their daily divergence from, and nightly return to, perpendicularity, would have been a perfect mystery. That they should bend away from the sun, as if pushed over by him, and not recover their previous position till he sank out of sight, would have been as inexplicable as attraction and repulsion.

The daily effect of solar heat on the crust of the earth must be prodigious. If a few soft morning rays, playing for

a few moments on a surface of stone, can raise thousands and multiplied millions of tons, the floods of heat pouring upon a hemisphere must proportionably elevate, or bulge out, the surface, and keep it, like the revolutionary column, in constant motion. What effect this is designed to have on the internal or external economy of the earth, we know not; but had she been made to turn on a fixed axle, it would have sufficed for her rotation, on the principle of those perpetual motion projects, in which weights are pushed out on the descending side of wheels and drawn in on the ascending sides.

But solar heat is not sufficient to meet all planetary requirements. While the great forces playing on the earth's surface are due to the sun, her stability and volume, and in some measure vegetable and animal life, depend upon heat generated within her. Indispensable as the heart is to a living being, her central fire has been much misunderstood. Because the force excited by it now and then shakes the ground, it has been held as simply destructive, whereas it is eminently and essentially conservative.* If the volume of the earth could have been kept stationary without it, there could have been no arts, because the materials most requisite are elaborated at depths for ever beyond human reach, and would have there remained. It is the expansion of matter by central heat that pushes them up.

Volcanic discharges are essential to our planet's vitality.

* The philosophy of earthquakes was studied by the ancients, and projects entertained for preventing them. Pliny mentions deep wells, dug to let out the imprisoned vapors. Indications of their approach were detected, and their appearance predicted for weeks and months beforehand, by Pythagoras and other keen observers.

would be inconceivably dark masses, upon which nothing that we know of could grow or live. His presence makes the day, his absence night; and who can fully appreciate the difference and results? To the sun we owe the seasons, and the mere change from summer to winter is from torpidity to activity—from life to death. What a change a few additional degrees of heat produce in the spring! Gushing fountains break their icy barriers, lakes and rivers absorb their frozen coverlids, vegetation starts along their margins, myriads upon myriads of insects are hatched into life, the blood of plants and animals courses through their veins, birds begin to carol, and the whole face of nature to be lit up with joy.

In fine, the sun is the soul of the system; that which makes, or is destined to make, each planet a paradise; without which there could be no arts, science, nor, in fact, human or animal existence on any of them. Reflect on what is comprehended in his being the cause of light, heat, colors, forces, and motions, and that without him there could not be even mental or moral perceptions and enjoyments; and then imagine, if you can, a more glorious application of the greater part of the inorganic matter of the universe. Think you this an ignoble or gross kind of work for suns to do for non-luminous orbs, in addition to being themselves birth-places and homes, as we believe they are, for intelligences specially adapted to them. For whatever they do for planets in no wise diminishes their domestic energies and functions. They are in truth Astral Fountains of mental and moral as well as of material Forces.

Although the law which governed the amount of matter and its volume in each sphere of our system is among the pro-

blems for the future, some of its advantages are apparent. The sun, for example, with undiminished splendor, would not have been so efficient a radiator of heat and light, had his dimensions been much less; a fact which favors the opinion of his moderate density. While the matter in him, it has been said, would only make 355,000, his bulk is equal to 1,402,000 earths. One direct result of this surpassing magnitude is, more than half of each planet is illumined at the same time. Atmospheric refraction increases this effect, so that a zone of the earth, sixty miles wide, is added to her illuminated half.

CHAPTER IX.

Problem of heat—Theory—Facilities of inquiry—Heat present in all bodies—Not a substance—An effect of FRICTION—Evolved from all natural motions—Specific heats—Grassi and Galileo—Substances fired by friction—Operations in the arts and agriculture frictional—Nature's processes for generating heat at large—The earth an apparatus—Ceaseless circulation of matter through her heated centre—Crude notions of her interior, and equatorial bulge—Other errors exploded—Facts confirmatory of the proposed theory—Contraction causing expansion—Great significance of those two terms—Electrical forms of heat—Results of friction—The earth, as a whole, a self-acting fire mill.

As force arises from expansion, and expansion from heat, the questions now occur, What is heat? How is it produced? By what means perpetuated? Problems these, of the highest import, for the heat of the earth is the mechanical force of the earth, and the sum of the heat of the spheres that of the universe.

We may be sure that heat, being universal as matter, is in its origin and effects one and the same everywhere: on our orb as on other planets, in the sun as in the rest of the stars. It may differ in its manifestations and intensities, but that no more affects its nature than different tones affect sound, or different speeds motion.

The theory that accounts for heat must agree with the diversity of its forms and intensities. The process of its

evolution must be adapted to matter in all conditions, and be in continual operation in the heavens and the earth, for the ceaseless renewal of an expended result must have a perpetually producing cause; one traceable to an unquestionable attribute of atoms, and in perfect accordance with the evolution of force, since heat and force reciprocally produce each other, the measure of one being that of the other.

As respects facilities for investigation, occupants of the spheres are probably on an equal footing. We see nothing and know of nothing in the heavens, to induce us to think heat can be more successfully studied elsewhere than here. Our earth is not only a specimen but a type of the universe, in the diversity of its contents, its mechanisms and motions, gravitation of its materials, diverse densities of its strata; its figure, unity, everlasting journeyings in the firmament, and in its heat.

All known bodies contain heat, be their conditions, forms, qualities, and quantities what they may. In the three general divisions of mundane matter the quantity differs materially. In vegetation it is very moderate, in the living kingdom somewhat extended, and in inorganic matter apparently illimitable. In every department it is being constantly expended and being ever renewed—a fact that bears against its materiality.

What is heat? The term 'caloric' has been adopted to designate its materiality; a proposition seriously questioned. It is evolved by mechanical action without addition or diminution of matter, and is without sensible weight or inertia. A bar of iron placed upon an anvil and struck with a hammer gives out a sharp ringing sound; increase the hammer-

ing and it gives out heat. If heat is matter, must not sound be matter also—are not both in the same category? We think they are, and that they are effects, not causes—results, not substances. Everything recognised by sense is not material: A person is tall, strong, industrious, he speaks, laughs, groans, dies; but stature, strength, labor, language, pleasure, pain, &c., are not therefore atomic compounds. Not one of them can be separated from the individual; neither can sound, heat, nor motion be exhibited alone.

Whence comes heat? We should say: FROM THE FRICTION OF MOLECULES WHICH PRESSURE INDUCES—friction arising from the mobility of atoms and gravitation of matter, and therefore incessant, universal, eternal.

Friction is the accompaniment or result of all motion, and nothing can be moved without evolving heat. Our perceptions are too blunt to detect increased temperature from the smallest disturbances, but we are quickly sensible of it on rubbing the hands together, or drawing them smartly over any part of the body. Physical exertion raises the temperature of the whole body. Laborers perspire in the coldest weather, and hard-driven horses are bathed in sweat and foam. But every motion, voluntary and involuntary, moves some organ or fibre, and generates heat by the friction of the parts. The play of the muscles, circulation of the blood, action of the heart, mastication and digestion of food, &c., rub molecules against molecules, and substance against substance.

Here we perceive the connexion between heat and force—how one generates the other—how, in the very expenditure of force in the movements of bodies, natural and artificial heat is given out.

The locomotion of animals consists altogether of frictional movements, whether engaged in dividing the water, cleaving the air, treading on the ground, or burrowing in it.

The vegetable kingdom presents in other phases the same thing.

But the mineral world illustrates the evolution and effects of heat from nature's zero up to the hottest sun. As there is no motion without heat, the smallest particles in motion must produce it, though in infinitesimal quantities. Molecular action (its source) varies in different substances, and one result of this is, the diverse *natural temperatures* contemplated under the name of specific heats. That is, the specific heat of a body is the effect and the measure of the attrition of its molecules. If this be so, and we had the means of detecting the slightest changes, substances whose molecular structure is artificially deranged (hammered metals for example) should corroborate it.

We can only account for the different states in which matter appears by the quantity of heat they contain. Some bodies are known to be more susceptible of it than others, and are counted good conductors, as silver, copper, &c. This conducting power is supposed to be due to the continuity of the molecules, as it appears to grow less as the interstices between them become greater—as in wool, hair, gases, &c.

The idea of heat being a result of motion is an old one. The Jesuit Grassi, who wrote against Galileo, quoted, or pretended to quote a story from Suidas, of the Babylonians cooking eggs by whirling then rapidly in a sling, in support of his argument that *motion always produces heat.* Galileo, without denying the proposition, ridiculed the illustration.

The heat from the friction of the air, he observed, would not prevent hot ones from becoming cold.

Examples need not be quoted of substances fired by friction, since they are of common occurrence—wooden axles, cables, lines attached to whaling harpoons, the 'ways' of launching ships, &c. The modern friction match is an improvement on the primeval mode of rubbing one dry stick over another. The temperature of cold water is raised by simply agitating it.* Ice rubbed on ice generates heat, and friction in place of fuel has been proposed to raise steam and warm buildings. In fine, light, electricity, and every other form of heat is producible by mechanical power,—that is by friction, for mechanical and chemical action are referable to it—impossible without it. A cannon-ball would become red-hot in passing through the air if the velocity could be sufficiently increased, and its surface even fused like that of a meteorite.

Then are not all operations in the arts—carding, spinning, weaving, sewing, cutting, carving, sawing, drilling, painting, scraping, turning, grinding, polishing, &c.,—frictional processes? In many of them velocities are limited on account of the evolution of heat, and in others cold water is employed to prevent its accumulation. To diminish friction

* A series of experiments by the celebrated George Rennie, F.R.S., &c., &c., 'On the quantity of heat developed by water when violently agitated' is now in progress. As the heat evolved depends on the pressure under which the agitated molecules operate, the *thickening* of a fluid would, we suppose, be analogous to an increase of pressure on rubbing solids. Water and sand in diverse proportions might be used; also sand alone and other dry fluids. But the plan of Mr. Rennie no doubt covers the whole ground.

we apply slippery compounds to working parts of artificial machines, and use unguents to loosen the joints and make supple the sinews of living ones; but there is nothing wherewith to lubricate molecules and make them glide more readily over one another.

Agricultural implements are frictional ones, from the plough and harrow to the reaper, rake, corn-sheller, and grist mill. In the course of experiments on mould-boards before the English Royal Agricultural Society, all the ploughs selected for trial were brought to a stand on attempting to work a strong clay soil. The cause of failure was this: the chief resistance to the horses in ploughing proceeded not from the weight of the earth moved, but from *friction* and cohesion.

Some have supposed there is no friction in rolling mechanisms. There may be none that can be detected, but it is impossible for any, the finest, movement to exist without it. Two wheels rolling on each other have a rubbing action, though imperceptible. Besides, all things turn in air. There can be no *pressure* without friction—without a displacement of molecules.

What is there that is not worn out by friction? To say nothing of our bodies, our furniture, clothing, dwellings, &c., there is the enormous amount of metals that disappears in ordinary hardware, domestic utensils, cutlery, edge tools, manufacturing and agricultural implements and processes, carriage tires, horse shoes, wheels of cars and rails; all being worn out by friction, and giving out heat as they are worn. Not hundreds, or thousands, but millions of tons of iron are annually required to meet the wear and tear of that metal alone.

As in the case of the projectile, it would be an interesting problem to determine how much heat a ton of iron gives out in the process of being dissipated by friction from railroads; and the inquiry might be profitably extended to other materials consumed in the arts, and also into nature's domains. People are startled at active volcanoes, but who dreams of the heat nature is silently adding to her stock in imperceptible movements?

By ordinary pressure, and by percussion—a form of pressure—wood and metals are heated, and tinder is kindled by condensed air in a syringe: examples, these, of heat artificially produced by mechanical force. Compare them with one of nature's ordinary generators. Imagine a compressing cylinder some four thousand miles high, of the same diameter, and charged to the brim with conglomerate masses, which masses serve as a piston and their weight as the force that pushes it down. The heat evolved by friction at the bottom fuses, if not flashes into vapor, everything there. The elastic fluids generated open passages, where the resistance from the miscellaneous character of the material is the least, for the ascent of the heated products to the surface; where, cooling and condensing, they are prepared to descend again. Thus the generation of heat and circulation of the material never stops.

As respects the principle and the process, the earth is such an apparatus, but in its form and operation infinitely more perfect. Gravity crowds her material into smaller and smaller areas as it approaches the centre, and there the extremest of mundane heat is engendered by abrasion under the concurrent pressure of the entire mass; one result of which is obvious in volcanoes and the streams of lava and

other matter they discharge. It is possible that some readers may concede this generation of central heat, and yet doubt its maintenance. The matter thus rendered incandescent, liquid, or gaseous, must, they think, grow colder by radiation like a mass on the surface. The mistake lies in contemplating it as stationary or stagnant, forgetting that expansion is constantly removing it, and a ceaseless exchange of heated matter for cold going on—that from this cause the whole material of the earth is always in motion—some *towards* and some *from* the centre—that fresh heat is as copiously generated now, as it ever was or can be; and that every mundane atom may have passed time and again through the furnace.

There is no room to question the reality of the circulation. Of the *rising* of matter, every part of the earth furnishes evidence in marine formations found in the midst of continents and on the summits of the highest mountains. Where is there not sand and gravel, and limestone composed of shells and corals? To say nothing of volcanoes and other visible discharges of internal matter upon the surface, we have coal, granite, metals, and other substances, elaborated at vast depths, raised up within our reach; and then there is the general rising of large districts of land now known to be actually going on. Nor is the *downward* movement less obvious, either upon or below the surface, as the abrasion of mountains by rain and the carrying down of the *detritus* to lower levels and to the ocean itself by rivers; ancient cities more or less buried, and some, like submerged forests, wholly disappeared; the position of geological strata, all descending with their fossil treasures in the order of their appearance at the surface; the oldest the lowest down, and the latest

immediately beneath the existing one. In all countries they are found thus following each other in regular succession, so that at this day, as in all preceding times, internal matter is coming up and external matter going down.

The same principle is at work in everything. Our bodies do not consist for a day of the same identical atoms. Not a particle of the child remains in the man; and that heat is the inducing cause is evinced in the renewal being more active in summer than in winter, in the tropics than in cold regions, more rapid in children than in adults, and slowest in the aged. But take the soil of the earth as an example. It is the *debris* of rocks protruded from below, the functions assigned to it being incompatible with its rock condition. It supplies material for vegetable and living forms, and hence, not till it became sufficiently comminuted did they appear. It circulates through them, but is not confined to them. It is ever changing. The present layer of soil is not that of which the first races of men were made; not a particle of it. Nor will it remain on the surface to enter the bodies of our immediate successors. Under the existing constitution of creation, it can neither remain permanent nor be permanently prolific, hence its descent also into the central purifying and regenerating fire.

This circulation, an inevitable result of gravitation, is, we believe, a fundamental feature in the constitution of the spheres. But for it more than half the material of the universe would be comparatively of no present value. Take the earth as an example. By far the greater part of her mass would serve no other purpose than a foundation for a thin stratum of surface material. Or, at most, it would be like surplus raw stock, stored away in a manufacturer's cellar. Now

were such the case, it would be equivalent to waste; for making little or no use of material, is much the same as expending it at the grossest disadvantage. But nothing of the kind occurs or can occur. There is not a particle of matter within her that is not doing work as essential to her economy and well-being as anything done on her surface. Without internal action, there could be no external developments. All the materials of her mineral, vegetable, and living forms are elaborated below, and, by the process described, made to circulate without ceasing. Spheres are in this respect what vegetable and animal bodies are.

Apply this doctrine to the heavens at large, and the conclusion is, that there is not an atom in the universe unemployed for one moment, or uselessly employed.

For lack of the knowledge of this interchange between the internal and external matter of spheres, what errors have obtained! With many, an ocean of melted lava still occupies the earth's centre, though for what purpose no one suggests, except those old and modern theological dreamers who make it out to be Tartarus. With them the 'shell theory' is everything. Various have been the hypotheses respecting Hell; but the old doctrine that the earth's heated centre was ordained to receive the sinners on her surface still prevails. According to a recent sermon "On Hell," delivered in New York and widely published in the papers, we are all within twenty-two miles of the place of torment—the crust of the earth not exceeding twenty-one miles in thickness. The learned preacher said nothing about the suburban Purgatory, the reality of which forms a prime article in the creed of his church.

'Hell is in the centre of the earth, and in it is a fire tor-

menting the damned; *therefore* the earth moves,' was one of the propositions broached in the Copernican controversies.

The doctrine was in olden time used to define boundaries in the conveyance of land. William the Conqueror granted to one of his friends

> 'The Hoppe and Hopetoune
> And al the land up and doune
> Under the earthe to Helle
> Above the earthe to Heaven.'
>
> —BLOUNT'S ANCIENT TENURES.

The general impression among writers on the theory of the earth still is that it is largely hollow, and not a few make it a mere crust or shell. The action of volcanoes they deem excavating processes, and strangely conclude that the vacancies have never been filled. Had this been so, our planet by this time had been swelled to bursting, like a soap bubble. The author of an interesting volume recently published, entitled 'The Universe no Desert, the Earth no Monopoly,' thus speaks of volcanoes:

'Now, if all these mighty engines, innumerably scattered over the globe, and in ranges of different heights and forces, succeeding each other through a series of countless ages, have been in active operation almost from the dawn of creation nearly up to the present time, pumping out the internal contents of the earth in prodigious volumes, to be cooled, hardened, and solidified into an exterior integument, so much less matter must, of course, be left inside, and by so much more must the crust have increased in thickness. Hence, rarer contents, or one or more cavities, must consequently have supervened this enormous draught; and the earth's

circumference must be greater than it was at some previous periods during its cooling process.'

Another opinion ascribes the bulge at the equator to a fluid or semi-fluid condition of the earth, arising from intense heat; in other words, to a molten mass, which, on cooling, retained the protuberant feature, like an artificial casting. But, instead of a homogeneous and compact mass, the earth's materials are loose and dissimilar, nor was it necessary they should ever have been otherwise to form the bulge. If just beginning to rotate, she would assume it now, and in all probability as imperceptibly to us as the present rising of the surface is to the people of northern Europe.

Besides exploding popular errors, does not the proposed theory correct some entertained by scientific men; *e. g.* that the mean temperature of the earth is much lower than it once was, and is gradually *decreasing?* Among other alleged proofs of minor import, the condition of primitive rocks is quoted. Once in a state of fusion, they have become solidified by the abstraction of heat, and representing, as they are supposed to do, the primitive earth, its heat is deemed to have been dissipating with the congelation of granite and other Plutonic formations. The hypothesis is alarming, since it involves eventually a fall of temperature below what is essential to animal and vegetable existence. (Thus the world is threatened by two sets of terrorists; one prophesying extinction of life by fire, the other by freezing.) Doubtless all mundane matter has been liquified by heat, but not at once. So every part has, seriatim, been under water, as part now is.

By what other scheme than the one proposed, can a satisfactory explanation be found for the continued heat and

internal movements of our planet, her volcanoes, rising and falling of the surface, and kindred phenomena? Do they not all proclaim a permanent, not an expiring or expired cause? It has been justly observed, that as the lava in Stromboli has been in a state of ignition for two thousand years, there must be a constant *accession* of heat from some source or other, if not a renovation of fuel.

Had the theory of friction been contemplated in connexion with the circulation of the earth's materials through her heated centre, on the same principle and from the same cause as water circulates in a boiling caldron—infinitely slower, it is true, but not less certain—the origin of heat in friction had not remained in doubt.

If the theory be the true one, the earth's temperature should increase regularly downwards, and such is known to be the fact. The ratio deduced from experiments in Artesian wells, and the deepest of salt and coal mines, indicates a temperature sufficient to liquify and disperse in vapor every known solid, at a less depth than one-thirtieth of her radius. What its intensity is at the centre, or halfway, or one-tenth or twentieth of the way to it, no one can, for want of data, determine, or for want of terms express.

The general heat of the earth's mass has been ascribed to radiation from its igneous core. To some slight extent this might possibly be admitted; but were there no glowing nucleus the temperature would increase downwards. Every stratum would be warmer than the one above it, because subject to greater pressure. The great cause is without, not within. Nor is one stratum a depôt of heat for another. The quantity each contains is for its own consumption, while

to the central font special functions are assigned, of which some have been indicated.

It follows that the temperature should be greatest at those parts of surface masses which endure the greatest pressure—greater in the interior of a mountain's base than near the apex. Are not the thundering explosions or displacements of ice mountains in polar circles due to this cause? Does not heat generated by pressure limit even such accumulations?

Is there not provision made against the escape of heat from the planets? They are enveloped in non-conducting atmospheres whose outer borders must be as void of heat as the ether that joins them. They generate all they want, and lose none. That the heat of the moon should not be detected by the most sensitive of instruments is what might be expected. The heat of the earth cannot, we suppose, be felt upon it.

But another and most interesting fact in relation to this subject is that of a property of matter eliciting an opposite one! It is incontestable, and pregnant with instruction. We might have inferred *à priori* that the power which compresses gaseous matter into concrete spheres must be arrested some way or other, but we never could have known, except from observation and experiment, that contraction gives birth to expansion.

The words 'contraction' and 'expansion' are of high significance in physics, since all motions on the earth and in the heavens are comprised in them. Representative terms, they are characteristic of the prevailing forces of the early and the present universe. When gravitation was performing its first grand task of breaking up the primordial nebula

into revolving spheres, the process was one of contraction; but when the material became consolidated into compact masses, it was reversed. As before there was nothing to be dilated, so now there was nothing to be further condensed.

As a form of heat, electricity should be evolved by friction, and it is. It was discovered by friction; the earliest and latest machines produce it by friction; the 'rubber' or 'cushion' is a *sine quâ non* in them all. Heat is evolved by mechanical force, and so is electricity: magneto-electric machines worked by hand or other power, give it out in unlimited quantities. It is developed extensively in paper-mills, cotton, woollen, cloth, and other factories; and is so abundantly evolved by brushes bearing on machine belting of gutta percha and vulcanized caoutchouc as to have raised hopes in some minds of a new motive power. Voltaic electricity is the result of molecular friction induced by chemical decomposition. Steel drills become magnetic while at work, and retain fringes of iron drillings on their edges till they become cooled.

The atmosphere is an exhaustless fountain of it. Every motion that induces attrition of its particles produces it. It is evolved by dragging the feet over a carpet, and in drilling of metals and other operations of the workshop. It is copiously generated by the escape of steam, compressed air, liquid carbonic acid, &c. The violent attrition of the escaping molecules in such cases renders it apparent, but there is no reason to infer that it does not proceed from the slowest of movements. In this, as in other matters, the most sensitive of tests soon fail, as they are of very limited application. We suppose vegetable, mineral, and animal forms are all

generating it. In a word, that motion is impossible without friction, and friction without electricity.

Thus, if we contemplate our planet simply as a producer of heat, she appears as if made for no other purpose. We perceive the infinities of her living, vegetable, and mineral mechanisms, all giving it out: and then, without interfering with the operations of one of these, we find this mundane mass constituting a great self-acting FIRE-MILL, evolving it in volumes, or quantities, immeasurably surpassing the yield of its myriads of minor producers. Or, viewed as a generator of electrical heat, she is full of devices for producing it, and as a whole performing the part of a vast one, revolving on her axis with the atmosphere as a cushion, and the cushion itself rubbing against the ether.

CHAPTER X.

The earth one of the smallest of planetary fire-mills—Solar heat evolved by friction—The theory sufficient for all orbs—Solar heat the common heat of the universe—The pressure of the sun's mass sufficient to account for his heat—Sirius—Gradual development of heat and light—Planets imperfect suns—Questions respecting the sun—Luminous atmosphere—Frictional theory resolves heat and force into universal gravitation—Creation consists of hot matter.

WONDERFUL as a Fire-mill our earth may appear, it dwindles into insignificance when compared with others. It would require a thousand such masses to make one equal to Saturn, and thirteen hundred to rival Jupiter in bulk. Of Jupiter's moons one is larger than Mercury, and one of Saturn's is held little less than Mars. As heat is the inevitable result of mobility and gravitation, every celestial mass, be its condition what it may, and whether the scene of life or not, is generating it. And what a multitude of these mills are at work even within the solar system, all operating on one plan and differing only in dimensions! All grinding out heat silently and without intermission! Still, incalculable as the aggregate amount engendered by them is, it falls vastly short of that ground out by the sun.

Is solar heat, then, produced in the same way? How else should it be? What is there in it or about it that requires or suggests a different process? Not the magnitude of the sun surely, for on that ground the largest of the planets

should have one differing from the least. As there is believed to be but one original source of heat, there is, we suppose, but one original mode of eliciting it. The difficulty lies chiefly in our slowness to admit, and timidity in appealing to, the indefinite extension of properties and conditions of matter. It is thus that we are led to think the sources of terrestrial must be insufficient for celestial heat; and if the sun has occupants of equally limited views they are probably reversing the proposition.

If the frictional theory be sufficient for the earth, it is for the universe. According to it the sun's heat ought to be, *at least*, as much more than that of the earth as his mass exceeds hers. How much is that? Astronomers differ about the sun's density. Some deem it equal to that of Mercury, others make it much less than that of our orb. At the lowest estimate, his material, if divided into masses of the size and solidity of the earth, would make nearly three hundred and fifty-five thousand of them. Then there is something more: one pound of terrestrial matter would exert a pressure of nearly twenty-eight pounds on the solar orb; thus multiplying still further the prodigious heat-engendering power of such a body. But other calculations make the sun equal to nearly a million and a half of earths, thus bewildering us completely in attempting to comprehend the products of such a Fire generator.

That we may not make our little experiences and feelings criteria for nature beyond our own domicile, we should bear in mind that solar heat is the *common heat* of *the universe;* the matter wrought into planets being very small in amount compared to that embodied in suns. Occupants of a minute and non-luminous mass, we naturally contemplate the sun

with admiration, but this excitement in its favor is like that of the savage comparing an argand lamp in the focus of a parabolic mirror with the pine splinters in his wigwam. And like him, too, we are disposed to attribute the superior light to a superior source.

As both sun and planets were formed out of the same material, the differences in their concrete conditions may be supposed to be due to the different treatment (pressure) it undergoes in consequence of diversity in the masses. When this is duly considered it will be found that the peculiar properties of the solar orb are no more than what might have been looked for. The greater the pressure of a mass the greater the heat, and the greater the mass, the greater the pressure. The material gathered into the sun constituted the centre of the nebula of the system, and was from the beginning subject to the pressure of the whole. From the utmost verge beyond Neptune, the whole concurred in compressing it ere the first born of the planets was formed, and the process ceased not till the last was thrown off. According to this theory the planets should increase in density as they approach the centre, and reasoning from analogy, the sun should in this respect surpass the densest. But whether or not, the material at the centre of his mass has undergone, and is now undergoing, pressure sufficient to account, in the way already mentioned, for his fervent heat.

Experiments give an increase of one degree of Fahrenheit's thermometer for every forty or fifty feet of vertical descent into the earth, after passing the thin stratum of constant temperature. Admitting this rate of increase, the earth's central heat would be expressed by three thousand degrees of Wedgwood's pyrometer,—an unimaginable intensity, for

one hundred degrees of the same scale suffices to melt most or all of the rocks. Apply this rule to the sun, and his temperature would be to the fiercest heat raging at the earth's centre as 883,000 is to 8,000. But such a heat, defying, as it does, all scales and calculations, is believed to be immeasurably short of the reality.

On first contemplating our earth as a generator of heat, its magnitude amazed us. What is it now? And what if there are stars as much greater than our sun as it exceeds the earth! It is not impossible. Sirius, whose brilliancy vastly surpasses that of our sun, was formerly supposed to be the nearest. Now, it is known that Alpha Centauri, 61 Cygni, and Vega are nearer, and the latter by ten billions of miles. Yet Sirius retains the preëminence. What must his magnitude then be, and who can imagine the intensity of friction and its resultant heat at his centre!

It may probably be said: If the heat and light of suns are simply the effects of the vastness of their masses should not the effects be proportionally produced in smaller bodies? Yes: but it does not follow that they should be recognisable. Heat, like everything else, rises and falls by degrees. It does not descend at a leap from brightness to blackness, nor spring at once from the latter to the former; and as for light, it is the concomitant of heat, the result and indicator of its higher intensities. It may exist in low ones, but it only becomes amenable to our perceptions when incandescence sets in. A common iron ball, in the process of being heated internally in the dark, grows warm, hot, assumes a darkish red color and then first becomes visible, puts on a brighter red, changes to pale white, and finally is at a dazzling whiteness that irradiates an extended area. Like it, at

low temperatures, planets are dark masses. It is only at what we may call extreme heats that light is given out, either artificially or in the heavens. It abounds only in suns, because their masses are alone sufficient to elicit it.

In one respect planets are a species of imperfect suns. At all events, each is a type of the system to which it belongs. The glowing centre of the earth is a sun to the encircling strata, and is indispensable to its internal as the celestial sun is to its external functions. Besides preventing further condensation it elaborates matter, as already stated, for organized bodies. Its effects, too, are confined to the planet like those of the sun to the system.

Though persuaded that friction is the source of solar heat, it is readily admitted that difficulties of explanation exist respecting the sun. It would be surprising if it were not so, since we are unable to determine many things relating to the moon close to us—difficulties, however, which we may hope will eventually be reconciled with the proposed theory, and with the inhabitability of suns. It is a question with astronomers, whether our sun's heat be reflected from his atmosphere, leaving his surface at a temperature not necessarily exceeding that of a planet; and certainly something like this is required by the Frictional theory: That is, time is required for matter heated at the centre to cool in approaching the surface, and become completely condensed upon it, before descending to the alembic again.

As has been observed, the grand external function of the sun is to warm and illumine the planets, and this requires the heating power at or near his surface, the reverse of the planets which employ it at their centres. That the heat reflected on his satellites is from his exterior does not admit of doubt.

How is it accomplished? Possibly from gases that inflame in the highest regions of his atmosphere, perhaps evolved from peculiarly constituted matter, arising from a moderately heated surface, and of course not incompatible with solar life. This might be perfectly consistent with the solar surface being no warmer than our earth at the equator or in temperate zones.

It is admitted by Sir John Herschel as probable that the luminous stratum of the solar atmosphere is sustained far above the body of the orb by a transparent elastic medium, which interposes as a screen to protect the surface from the heat; that while it is possible the surface may be in a state of intense ignition, it does not follow of necessity that it must be so. The contrary is at least physically possible. A perfectly reflective canopy would effectually defend it from the radiation of the luminous regions above, that no heat could be conducted downwards through a gaseous medium increasing rapidly in density—and that the penumbral clouds *are* highly reflective, the fact of their visibility in such a situation can leave no doubt.

But let the physical condition of the sun be what it may, does not the theory of friction account for the perpetual generation of solar as of planetary heat? The greater intensity of one is what ought to, and inevitably must, arise from the superior energy of the exciting cause. Can another be suggested more consistent with observation, experience, philosophy, and known facts? It accounts for the conversion of the frigid primordial nebula into heat and light generating spheres; accords with every possible form and condition of matter, and meets all exigencies. It evolves the force of the universe from the gravity of its masses, eliciting the most active from the most passive of principles. It makes heat and gravi-

tation the two grand controlling influences of creation, and, while supposing all motions to arise from conflicts between them, derives one from the other. That is, it makes heat and force coextensive with and enduring as matter, and, whether weight be an incident or an attribute, resolves them into UNIVERSAL GRAVITATION.

There is one characteristic of a true theory that might have been dwelt on—the connexion of the greatest with the least manifestations of heat. Friction shows that we all have at our fingers' ends the secret of its origin, maintenance, and perpetuity.

Nothing is more obvious than the fact that the universe consists of *hot* matter; that heat is as necessary to planets as to suns, and hence our earth is suffused with it. An intensely heated mass, her superstratum only is moderately cool. Upon her nothing can be done without heat, nothing elaborated, and nothing moved: for while she is alive within with inorganic forces, and her surface swarming with living ones, they all proceed from heat. To maintain them her material is placed between two inextinguishable fires—her glowing centre and the Sun. The function of one is to evolve her surface products, and that of the other to prepare and push up material for them; for which purpose it was necessary that the heat (in other words the force) should increase with the depth. Such appears to be the general process by which mundane, and it is presumed all planetary matter, is rendered permanently prolific of mineral, vegetable, and living forms. The arrangements are such that, let geographical and geological mutations be what they may, nothing can interfere with the process and its results.

CHAPTER XI.

Gravitation and its offspring heat—Force works in diverse phases in a circle. Coal the talisman for invoking force—Coal and water chief gifts to artisan man—Man on the earth's surface and his stock of materials beneath him—Heat breaks down all bodies—Carries force over unlimited distances—Transit of solar heat—As the representative of force no heat lost in space—Velocity of force in the form of heat—Sympathy misplaced—Saying of Galileo.

In a preceding chapter we arrived at the conclusion that force consists in the swelling and shrinking of matter; there being no other possible action by which a passive can become a motive body. And further, that force is not, and cannot be kept up by one without the other. No bodies are for ever expanding or contracting, and if there were such their force would be for ever diminishing. Force is therefore maintained by the alternate preponderance of one action over the other. Matter shrinks under an external and swells from an internal power. Gravitation is the first, and it generates the second. It is the weight that moves the clockwork of the universe, and, by its offspring *heat*, is ever winding it up.

Then heat is resolved into molecular excitement; intense heat being simply intense motion, and expansion a widening of the spaces between molecules in consequence of increasing velocities of the latter urging them outwards. Heat and motion are therefore one and the same. Thus it would seem

that Force passes through diverse phases in a *circle*;—gravitation, compression, friction, heat, expansion, loss of heat, and then gravitation again. It is everywhere present in one phase or another, and in the act of passing from one to another. Hence we again perceive how the smallest orb in space, if it contain matter enough to liquify solids at its centre, is a constant scene of these changes. Its own furnace and fuel, the circulation of its materials is perpetual. And the modus operandi, how simple and satisfactory!

If nothing is more important, nothing is more abundant, than heat. We have seen how, for her own use, Nature's great fountains are ever pouring it out, while for man she has provided means to excite it when it is not excited by her. What the solar furnace above, and the earth's central fires beneath him cannot do, he accomplishes by the combustion of fuel. By it he realizes an expansive force wherever he wills, and as for the provision he has only to turn to the exhaustless beds of coal, so carefully elaborated, preserved from intermixture with foreign substances, and raised within his reach. This is the talisman by which he invokes the antagonist of gravitation, and resists a power beyond his control.

In employing heat as a force, the latter is seldom derived directly from the fuel. Air is sometimes used as a medium, but generally water, which, in several respects, is the most convenient and efficient agent to receive and transmit the power. It is widely, and we think chiefly, used by nature for the same purpose. That we cannot employ the smoke and gases arising from burning fuel to impart motion to a piston is obvious; and in looking about for a suitable substance, one that readily and greatly dilates, is facile of

management, and everywhere to be had, nothing yet found is equal to *water;* and nothing equal to *coal* for expanding it into steam. The former is a common expanding agent in nature, and the latter is our best substitute for the sun to act upon it. There are no forms of mundane matter yet discovered that in all points equal these for the generation of force. They are the greatest treasures which God has given to artisan man. Hence it is perceived that though heat is the product of friction, instead of obtaining it by that process, which would cost us more power than it would yield, an inexhaustible supply of inflammable material is provided.

No greater problem has been solved in modern times than that which ascribes to COAL civil, political, commercial, and even moral power. All the circumstances connected with its history were prophetic of the great things to be accomplished by it in an advanced epoch of the arts—an epoch only now beginning to open. Indeed, in whatever light the disposition of mundane matter is viewed—its varied forms, qualities, quantities, and locations—it proclaims its adaptation to human exigences. The lord of the earth, man's position is upon it. Its surface furnishes him with food and clothing, room for his operations, and for limited amounts of material, but it is insufficient to receive all the substances that he requires. They would be in his way. The grand laboratory and store-room are below, and thence they are raised as they are wanted. Limestones and other rocks, minerals and metals are there prepared for him to work up, and in coal, force to assist him in working them up.

The history of the present century has brought out in strong relief the fact that mental and material progress depends on the employment of forces where natural ones are

not; and the other great fact, that provision is made for our realizing such to unlimited extents. We have evidence how low and fixed human condition was in the most advanced nations of old, and how stationary it still is in Persia, India, China, and other countries—for lack of knowing how to obtain force from common fuel, in addition to what is derivable from animals, water, and wind.

Heat is the *only* form of force that can resist or undo the work of gravitation. As this can neither be diminished nor evaded, how are liquid and concrete bodies to be re-expanded? Every person knows that this is done by infusing into them an amount of heat equivalent to that evolved in their condensation: as when we convert water into steam, liquify metals, &c. It is thus that heat enters where no material agent can go, and does what no other phase of force can do, and this to either organic or inorganic bodies.

There was another necessity: Without heat force could only have been conveyed over very limited distances. Except through currents of wind and water, the media by which it is conveyed to work assigned it seldom exceed a few feet in extent; in some departments a few inches, and often much less. We use flexible and inflexible materials to transmit power, but no belting or shafting could be used between us and the sun. And yet how quickly his power comes in the form of heat! How prompt its action on external nature!

Led by experience and the necessity of economizing fuel, we build furnaces as close as possible to the bodies they are to heat. Under few or no circumstances could one be available a hundred or even fifty feet off. How then are our little thoughts on the subject distanced by the practice of

the Divine Engineer, who has so placed the solar fire, that of the bodies it is intended to act on, the nearest is over thirty-six millions of miles off, and the furthest between two and three billions! How the elements of heat can avoid being dissipated before traversing a tithe of the shortest distance named seems inexplicable. To our limited faculties and experience the thing appears impossible. There is another embarrassing point: From the paramount importance of heat we should have supposed the planets would have been placed at the same distance from the sun—made to circulate in one circle around him—that all might be warmed and illumined alike, instead of extending them outwards at such vast and varying distances.

The first and obvious inference from this arrangement is that solar influence diminishes with distance, so that while Mercury and Venus are bathed in perpetual radiance, Uranus and Neptune are buried in eternal gloom. Now, to practical minds, reflection would at once suggest the improbability, if not impossibility, of such a result. They would infer that the heat and light provided for the planets *must* reach them undiminished in quantity and intensity, however incomprehensible to us the process may be. The idea of the object being imperfectly accomplished would be rejected, because their conclusion would be,—If the plan is not perfect, another had been adopted. A moderate acquaintance with the operations of nature would strengthen their convictions, since they would perceive how properties of matter, when carried to extremes, merge into their very opposites; and there are other facts which render it unsafe always to look for one definite result, when a thousand may intervene to modify and even reverse it.

The existence of a principle by which heat and light pass unaffected over unlimited spaces would inevitably occur. Reasoning from analogy they would say: Our gas lights are as brilliant miles away from the works as close to them. Their elements pass, impalpable to sense, through cold and dark tubing till ignited in jests; and may not natural light, from a kindred cause, be as strong on one orb as another? Generated in the solar retort, transmitted through the coldest and darkest of conduits, it is only flashed into flame when it reaches the planets, its natural 'burners.' There is nothing in distance to affect it. The constitution of the ether seems specially adapted for heat to pass through it without interception. It certainly absorbs none, for while solar rays have been playing through it from the beginning, it remains innately tenebrious, frigid, and passive. Its temperature was calculated by Fourier at 58° below zero.

Heat then is insensible or latent where there is no material or suitable material for it to act on. We feel it because surrounded by substances it affects, but it comes from the sun *undiminished* because *unexcited*. It passes through space till it strikes on bodies that reflect it—the planets for which it is designed—and may therefore be as intense on one as another.

A city has its gas-house centrally located. From it streets radiate, and to light them a lamp is planted every two or three hundred feet. We stand by one, and looking forward, the rows appear to diminish in brilliancy to the end of the vista. This is illusion, for we know the furthest light is in everything equal to the nearest. So with the planets. Their light is not to be judged of by their distance from the solar gas-house, but from the character of the lamp at which

it is kindled. The distance from which gas can be conveniently sent is limited, and to meet the exigence gas factories are multiplied; such, we may presume, had been the case in the heavens, if stellar light was weakened in its passage to planets.

It may be answered that this implies light to be material, or at least dependent on the issue of some subtle form of matter, the existence of which is by no means certain; but that, whether it exists or not, the doctrine of the planets being *simple reflectors*, placed at divers distances from the solar orb, and therefore necessarily reflecting less and less heat as they recede from him, is the more philosophical solution. Admit that it is, and the results may be as various as the reflectors, and in an increasing instead of a decreasing ratio. The reflecting power of the planets is known to vary, and to an extent that has led observers to the conclusion that it is greater the more distant the planet is from the sun, and hence, on this ground, to indicate the possibility of an equality of light on them all.

But whatever may be said of the transmission of heat and light, there is another view of the subject which, to practical minds, is irreconcilable with the doctrine that they diminish in proportion to the square of the distance from the luminous body. Such may be the law wherever they are *excited*, as within our atmosphere; but what proofs are there that it is the same in free space, where they are neither excited nor excitable. But passing this: the sun is not only the source of heat and light to the planets, but their grand fountain of FORCE. Are we to accept the formula as respects *it* also—admit that it dwindles down to nothing, or next to nothing, on the noblest of the group—that it grows less as they

grow larger and require it the more—that the greater part is expended on the way, which it must be, if heat is!

What engineer can indulge the thought that the author of the stellar generators of force had not the means of conveying it to its destination without loss; or, possessing the means, permit it to be diluted in the passage when there was nothing in the passage for it to do! His conviction would be that it passes intact to the planets.

Buried, as it were, at the bottom of a fluid medium, where solar heat and light are powerfully reflected, great is the presumption of applying rules which govern their manifestation here to other media and other worlds. So far from the dictum—the nearer the sun the greater the heat—being true, constant recurring facts contradict it. The higher we ascend in the atmosphere at the equator, the colder and darker it grows. But the earth is, at one part of the year, some three or four millions of miles nearer the sun than at another, and we all know she is then no warmer.

There was another exigence which force in the form of heat alone could meet—an exigence that could hardly have been imagined to extend beyond nature's operations, and yet it has been recently felt and met in the arts. In the electric telegraph the *velocity* with which force travels, in the form of heat, has been realized! Electric and electro-magnetic forces seem designed for unlimited velocities, and to pass over unlimited distances, from the grandest of movements to animal organizations and the vibrations of insects' wings.

Feelings bordering on pity have been excited in behalf of occupants of the outer planets, because of the supposed extreme gelidity and feeble glimmerings of light pervading those remote regions! At Neptune, the solar heat is calcu-

lated at $\frac{1}{900}$ of what we enjoy. At Uranus, the amount is stated at $\frac{1}{360}$, and at Saturn, and even Jupiter, so small as to be compatible only with low phases of vitality! Such are the results of hastily extending earthly demonstrations beyond the earth—of enacting laws for the system. And then to cap the climax of human eccentricity, these magnificent worlds are thus proscribed, and cursed with want of power, with barrenness and night, to make philosophy sustain religious dogmas of the day! One astronomer is found who prefers to depopulate the universe rather than suffer star or planet to throw the little ball we live on into shade.

Our investigations are confined, at the utmost, to limited areas, and from what we observe in them, we infer what passes beyond them. To some extent this may be safe; but creditable as human achievements in science are, how insignificant they appear when the mind rises above the globule we occupy to view creation at large. As soon will an insect cover the earth with its wings as man comprehend the universe. How great the error of those, says Galileo, who persist in making their knowledge and apprehension the measure of the apprehension and knowledge of God.

CHAPTER XII.

Every body influenced by two forces—Equality of internal and external force—Error respecting force—Relative amounts of force in the three departments of nature—More used in the Arts than ever—Diverse directions of force—Rotatory, curved, and straight motions, in Nature and Art.

It was the intention to close this book with the preceding page, as all that was designed to be included, had with it been introduced; but some miscellaneous memoranda, relating, though not directly, to the subject as originally contemplated, remaining unused, they are thrown together in this and the following chapter.

Every body, from a worm to a world, obeys at least two forces, a native and a foreign one, and consequently emanating from distinct sources. The first is internal and belongs to the individual, the second external and common to the species. This is not more obvious in plants and animals than in the earth at large. Her internal fires suffice for her internal movements, while the potent changes on her surface are due to energies not her own. For them, in common with her sister planets, she draws upon the sun. Thus it will be found that every body has a force proper to itself, and at the same time is subject to another that associates it with the class to which it belongs, and binds it to the universal whole.

Of the two divisions of force, as exemplified in the exter-

nal and internal movements of bodies, we are apt to confine our ideas to the former, because they alone strike the senses. We are not sure, however, that the silent and imperceptible are not equal in the aggregate to the palpable and gross. May there not be a definite relationship between them? The interior mechanisms of animals cease not, day or night, and when death ensues invisible forces are as active in the work of decomposition as they were in that of growth. In the constitution of bodies force never dies.

There may be as large an amount of force excited within and upon our earth as is equivalent to her orbital and axial movements, and so of every orb. The universe itself we have considered as a rotating sphere: like a planet its forces are expended within it, and they may be supposed to be equivalent to that of its rotation.

There are those who think that as bodies react on others, and they on others, no force is lost, that a wave of air from a bird's wing is sent through the universe, and that all the momenta expended by nature or employed in the arts circulate in like manner. Instead of holding force incidental to a change in the condition of a mass and *expiring with the change*, they view it somewhat as a substantial thing—objective rather than subjective—and sometimes in admiration ask, '*Where* is all the force of which the earth has been the theatre: that which heaved up its mountains, piled strata upon strata, scooped out channels for its rivers and basins for its lakes, covered its surface with forests, and renewed them as they decayed? And where is the incalculable amount of muscular power given out by extinct birds, fishes, quadrupeds, and men?' The answer is; It is where they are. It is no longer a reality, and can no more be recovered than they.

It expired, as it now expires, in the form, and survives in the elements. Were it not so, an amount might be accumulated on one orb to suffice for all.

The relative amounts of force at work in the three kingdoms of nature might be an instructive subject of inquiry. Whatever they are, we should judge, from the influence of civilization on climate, the destruction of forests and cultivation of their sites, the thinning out and even exterminating some living tribes, from the enormous product of modern sea-fishing and the increasing demand for animal products, that they are not uniformly maintained. Nor is it presumable that the quantity of force in each of the cardinal forms of matter—aeriform, liquid, and solid—is unchangeable. Still, there is no doubt a law which, admitting constant variations, maintains a constant mean—a conservative principle, without which the whole material of the orb might in time shrink into a solid or swell into a gas.

A larger amount of force artificially excited is now employed by man than at any previous epoch, but it is only transferred, as in nature, from one body to another. In doing this we simply anticipate her in the decomposition of the materials, and divert for our purpose a portion of the force that accompanies the change. Besides accelerating transformations of matter, all that man can do as respects force is to collect it from one body and concentrate it, directly or indirectly, upon another, and he is the greatest engineer who obtains and expends it with the greatest economy.

Although the directions of force, or forms of motion, are greatly varied, they may be resolved into perpetual and intermittent, straight, curved, and rotatory. The movements of the spheres are peculiar to them, being circular, ceaseless,

and uniform; while those upon them are straight and curved, alternating and unequal. At all events, such are the characteristics of those of our orb. We have, however, the means of converting irregular into regular, straight into curved, alternating into continuous, &c., and *vice versâ*. We have observed on a previous page that circular motion is the parent of all others, and the only universal one. The general classification of motion may be thus stated:

Rotatory in the heavens,
Curved in vegetable and animated nature,
Straight in the inorganic world, and

The whole of these and diverse combinations of them in artificial mechanisms.

Straight forces cannot be continuous, because of the impossibility of following them up with motal matter. We cannot push a vessel across the Atlantic by using her dock in New York as an abutment; for we have no means of sending out matter, solid or fluid, to keep impinging against her receding stern. An inflexible rod to thrust her out a few miles to sea would require more material than she contained; the disproportion would augment with the distance, and the effect be diminished with it. In all cases the prolongation of the motive agent is limited, and, in art as in nature, the shorter it is made the better.

When stationary forces will not answer, nature's plan is to make them locomotive, and in place of fixed fulcra she uses the medium over or through which a body is to move, as a continuous one. By it the distance between the mover and the moved is maintained invariable, whatever be the form of the motion; and the amount of material in the connecting mechanisms is reduced to a minimum, because the distance

between the force and the resistance is so reduced. In men walking, animals running, birds flying, and fishes swimming, the principle is obvious, and its application not less so in artificial locomotives. By transferring a steamer's abutment from her dock to the ocean itself, the objection of distance is annihilated.

In one class of cases the prolongation of the impelling agent is superseded by its sudden expansion against fixed bases, as in artillery and fire-arms. The principle is the same as when ashes are projected from volcanoes; the solid part of the earth beneath the expanding force acts the same part as the breech of the gun. Here the projectile leaves the motive fluid, having received, by a single impulse, momentum sufficient to carry it beyond the limits or influence of the expanding motor. A well known natural example of this principle of shooting game is the jaculator fish, and doubtless nature furnishes many more.

Straight forces, therefore, necessarily alternate, are interrupted and irregular. Reversing their directions, they are not adapted for rapid movements, and obviously not for large masses, as no small amount of force is lost in stopping and starting them: hence motion in right lines is not much used in artificial mechanisms, and assuredly is not conspicuous in natural ones. I doubt if it is found in the living world at all. Are there any propelling organs that are not essentially curvilinear?

It may be said that fluid matter expanding from fixed bases diverges in right lines. True, if the expansion takes place in a homogeneous medium, but where does this occur? In earthquakes, the direction of the radiating force is changed by the unequal resistance of the inclosure. So it is with

working steam. The fluid presses equally on the bottom and sides of the cylinder, but the piston presenting less resistance than other parts, yields soonest to the pressure, and the fluid is directed in a rectilinear direction, there being no other for it to move in. But how limited is its course! Only a few feet! A working cylinder a mile in length—and what is a mile in the transmission of force—would be useless, for steam could not act through it with effect, nor yet through one a hundred feet in length.

CHAPTER XIII.

Organic and inorganic forces—Animals—Their internal heat, and devices to preserve it—Their force due to combustion—Fat—Force portable in animals—Digesting apparatus—Moisture—Animals formed mostly of water—Allied to electric as well as to steam motors—Muscular power—A great book to be written—Analogy of food and fuel—No forces without them—Labor of animals and men to procure food—Provision for perpetual supplies of food and fuel.

NATURE is made up of two classes of Force generators—organic and inorganic. Of the latter one body moves another, while living machines move themselves.

Life is, we suppose, as much an effect of organization as color or crystallization. Molecules form animate as they form inanimate bodies; and though not alive in the sense of some early microscopists, the element of animation inheres in them as obviously as that of vegetable life in plants. The former is but an expansion of the latter. In both, bodies spring from germs, grow, mature, decay, and die; their motions are sustained by chemical decomposition, they require warmth, air, and food, and expire when deprived of either; without water plants perish of thirst as well as animals and men.

Animated nature presents the third and highest phase of material development. Although the same matter circulates

through the three, it is difficult to determine where one begins and ends, so imperceptibly do they glide into one another. There is, however, no difficulty in discriminating generally: Mineral bodies may be considered as inert; vegetables have some motion, but are chained to the ground; while animals are cut loose from it, and roam at their pleasure over it.

Every species of living forms requires a specific temperature. Life is impossible without heat. No animal could exist with an internal temperature below the freezing point. Its fluids would be frozen and digestion of food impossible, for as there is no heat without decomposition, there is no decomposition without heat. The range of living temperatures is very limited, and life is extinguished by slight variations. Travellers when exposed in high latitudes become drowsy, and those who yield to the sensation by lying down, seldom rise again. The provision made by nature to keep Arctic animals warm by coats of thick fur, feathers, and other non-conducting substances, is well known. Even fishes are lubricated with a varnish impervious to water, which prevents them from being chilled, although ceaselessly passing out of one cold bath into another. No animal can exist of one *uniform* temperature. The minutest must have a heat generator, or it could have no power to move.

In living as in other bodies heat is force. We all know that as man's heat is diminished, his natural force is abated, and how in remote times a knowledge of this fact led to diverse modes of keeping up heat in the aged. The prime source of animal heat and of nervous power is said to be in the chemical combination of the oxygen in the air they breathe and antagonist elements, arising from the decompo-

sition of their food. We require fuel to burn in the lungs: every breath we draw demands hydrogen, hence, if we do not eat *fat* in one form or another, the muscles and tissues are absorbed to supply its place. In the coldest regions, where heat is most required, fat is most abundant, and almost the only food.

Animals inhale air to aid in the combustion of food and evolution of force just as do artificial furnaces. Stop the draught in both, and both are suffocated.

Force is portable in animals. Each has a stock to serve for seasons of fasting more or less prolonged. When the wind dies out the ship is becalmed, when the dam ceases to flow the mill stands still, but animals are active for days, and some even for weeks, on the strength of one meal. What indeed would be the condition of things if our horses had to stop every few minutes to feed, or drop from exhaustion after an hour or two of labor; if mules were to give out in the mountains before half the day was expired, or camels faint between fountains of the desert? What if birds of flight expended their force before half their passage was accomplished! To meet such cases animals are endued with singular powers of endurance, and the fact is one of the most interesting connected with the economy of force. The tail of the Adel sheep (Ethiopia) is so copiously furnished with fat that the animal is said to be capable of subsisting an entire year upon the absorption of it.

The evolution of forces greatly varies in living tribes. Different food requires different treatment. In quadrupeds the grinding and digesting apparatus of carnivora are not the same as in vegetable feeders. But however diverse chemical and mechanical processes may be, every individual insect,

mammal, bird, reptile, or fish, acts independently in providing and preparing food, and consequently in generating force for itself.

There is, we suppose, no living force without moisture. Dry bodies may be moved, but the force that moves them is derived from wet ones. We know of no self-moving bodies of a perfectly arid nature, nor does it appear possible for one dry and crumbling as a mummy to live, or a plant either. Then no animal can be a uniform fluid or solid, but a compound of both, and hence every living thing, from mastodons to insects, is made up of concrete and liquid materials. All food is wet. No animal or insect could live on absolutely dry food.

Besides being full of juices, living bodies imbibe moisture as an element of force. Water the chief agent of expansion in inorganic forces, clearly plays an equally important part in living ones. They all drink it—the larger quadrupeds by pailfuls. Insects sip it, no birds can do without it, and fishes live in it. In deserts where it is not to be found the camel family carry reservoirs of it with them; and we follow their example in our locomotives. Indeed, the closer we examine natural and artificial motors the nearer they seem to approach in all essential points. Warm-blooded animals resemble steam-engines—and cold-blooded ones too, for they are only less warm than the others. The capacities of steam boilers bear certain proportions to their cylinders, and so do the working mechanisms of animals to their liquid reservoirs. Take our own species and more than three fourths of our bodies are water. Of the blood 78, of the flesh 75, and of the brain 80 per cent. is water. A corpse weighing 120 lbs. when thoroughly dried weighs but 10 to 12 lbs.,

so that the bones of an animal stripped of its muscle and moisture are in a like condition as the iron bones of an engine deprived of its boiler. Both are skeletons, without power to move a member.

The same may be said of plants, which are also composed chiefly of water. It is steam that invigorates them. Every night they are drenched with dew, which the sun dilates into vapor. Water and heat make them lively—in their absence they die.

But animals are not wholly steam machines. If they were, we could produce some tolerable copies. Their heat is more or less electrical, and hence their alliance to our electro-magnetic motors. That heat, light, electricity, and magnetism, play important parts in the work of living forces is known, though in what precise way aliment infuses vigor through the body is unknown. It has been thought that force *begins* in contracting or shortening the muscles beyond their natural tension, in contradistinction to expansion in inorganic forces.

Although muscular power is obedient to our wills, it acts independently of them in involuntary motions. The will directs force, but cannot generate it. If it could, men would never drop from exhaustion.

We see how force acts in driving a ball from a gun, how steam crowds against a piston and pushes it forward, and we understand, as well as if we were present, how, in like manner, matter is urged from the interior of the earth to her surface. These are, however, among the grossest phases of force. The expanding matter is tangible, visible, and the process of displacement obvious: but when we pass to the movements of organic bodies, we are at once at fault because of the subtlety of the metal agents and the mystery that

enshrouds their operations. Perhaps the greatest volume which man in his highest estate may ever produce, will be one explanatory of the mechanical structures, the propelling apparatus and powers of the earth's living forms. As yet, no one, we believe, can fully explain the mechanism of so much as an insect—say a common fly—or tell how its force is evolved, and how transmitted and applied to the moving parts. Nature conceals nothing, and she writes in legible characters, but they require study to get at their meaning. To most of us many of them are what printed pages are to those who cannot read.

It has naturally become an important branch of political economy, as well as of mechanical philosophy, to find those substances that give out force, or its equivalent heat, at the least cost; hence essays on the comparative value of staple materials used as fuel—turf, peat, various woods, coals, coke, charcoal, &c. And hence researches on food, its analysis, amount of nutrition in different kinds, &c. It is an interesting fact, and one that throws light on the unity of material forces, that the chief elements of food are those which enter most largely into the composition of ordinary combustible bodies. Carbon vastly preponderates, then oxygen, small proportions of nitrogen and still smaller of hydrogen, except in the case of fat, in which of 1000 parts not less than 780 are carbon, 122 hydrogen, and 98 oxygen. The fattest meat is the strongest, according to the experience of the world, and hence beef and pork are the principal items of army and navy stores. Beans and bacon form the national dish for many people, and if in the Arctic regions neither is known, the natives make up for the principal item in whale and seal oil, and blubber—materials most productive of

force whether consumed in human stomachs or in steam furnaces.

Animate, like inanimate and artificial, motors proclaim the immutable law that there can be no force without the decomposition of matter in one form or another, while to keep up the supply nature is unceasingly elaborating matter for organic or inorganic combustion—*Food* and *Fuel*. Then daily observation and experience prove that every increase of power can only be had by an increased outlay of the motive material. When grist mills flag, more water is turned upon the wheels; when steam motors labor, more coal is thrown under their boilers; in electric engines acid and zinc are added. When the wind slackens, more sails are exposed to its influence; when one animal is unable to drag a carriage or plough, another is yoked to the traces. The hardest worked horses, as omnibus hacks in cities, are fed oftener than others. It is the same with our own species: to field hands in harvest time an extra meal is sent; ordinary artisans working over hours require additional refreshments, and temporary demands for extra force are met by temporary stimulants. The athletæ of old, like modern pugilists, were trained by exercise and the strongest food for their professions.

Were it not that our feelings have ceased to be moved by creation's wonders, they would be excited by the provision made for securing the continuance of force in living organisms. These, having a will of their own to receive or reject food, would become extinct if not driven by resistless impulses to replenish their wasting powers; hence they are stimulated to forage for food by the gnawings of hunger, and with an avidity that increases with the need of it.

Life, with the lower tribes, is taken up in allaying the cravings of appetite, and no small part of all men's lives is thus devoted. What else are the pursuits of human masses but to replenish their wasting strength—ever striving to get bread and consuming it to get more. If yon plantation laborers are languidly creeping to their huts to sup and sleep, and gain fresh vigor for to-morrow, it is pretty much the same in the moils of city life: there, for the same purposes, workmen hurry to their homes, and crowd the restaurants.

It is childish to suppose there can ever be a lack of fuel or food. The arts may be extended indefinitely, and at some distant epoch the present stock of wood, peat, and coal, may be used up; but ere that time arrives equal amounts of the same things, or their equivalents, will have matured. As water raised in vapor comes back in rain, so all things else return, though through more circuitous processes. We might as well dream of the earth losing her fertility, and of the consequent failure of food. One deficiency is as likely to occur as the other, for the supply of food and fuel rests on the same basis.

But the timid and fearful have a richer field in which to enlarge their fears—in the outlay of fuel in the heavens. Infinite amounts ceaselessly consuming in the stars to keep up infinite expenditures of force. Those who have not reflected on this vast consumption might wonder how the universe has not, like our ancient forests, become exhausted to keep the solar furnaces in blast. But for one thing we believe such would have been the result. Nothing but the beautiful system of circulation of material in these fire-mills could have met the demand. In this respect our orb is a

type of others and of the universe at large. In the simple gravitation of its materials it has within itself the elements of everlasting fires and forces.

Finally, by the cardinal principle of circulation, matter for elaboration, as well as forces to elaborate it, is as exhaustless in the smallest as in the largest spheres.

THE END.

NOTES.

Variety in the constitution of atoms.—P. 24.

What is the latent power which moulds matter into organic and inorganic forms? And what is it that prevents the duplication of forms? Which prohibits even two grains of dust, or two blades of grass, from being exact counterparts of each other? A miracle apparently as great as the former.

It is admitted that natural forms make their appearance in accordance with principles, which it is the province of man to find out, and to trace in their operations; but while in most departments of knowledge he is only commencing his collegiate education, in this he is hardly prepared to enter the freshman's class, for that which evolves the contours and limits the dimensions of mineral, vegetable, and living bodies, is unknown. The science is yet a blank, though there is that in it which is destined to become one of the great crowning glories of human intelligence.

But though unprepared to undertake the first problem, we think the secret of the second is to be found in the fact that matter is never at rest, nor for two moments in one and the same condition, either as respects heat, motion, moisture, light, electricity, &c.; and hence as no two parcels or particles come under precisely the same influences, or degrees of influences, chemically or mechanically, no two bodies, or parts of bodies,

can through eternity be evolved alike—neither men, nor trees, nor leaves, nor clouds, nor aught else.

Suppose a number of germinating molecules placed in the same locations as a like previous number, their development would necessarily be different if for no other reason than the ground that received them having undergone changes which could not be recalled. A field is sown with the same kind of grain as last year. To all appearance the seeds are fac-similes of one another and of those they sprung from. They are dropped, in most cases, on the same spots as their predecessors; but the soil is not what it was, it is not in the same condition, nor is it composed wholly of the same elements; moreover, the air in contact with it has been changed, is still changing, and the state of the atmosphere over it also: the result is, that the ripened crop does not present a couple of stems, or ears, or grains, or husks, that do not differ from each other and from those of previous harvests, local or general.

But instead of a year's interim, kindred effects follow, though in degrees infinitely too minute for us to detect, after an interval of a week, a day, an hour, or a minute, since, as already intimated, neither seeds, nor soil, nor plants, nor animals, nor adjacent nor surrounding matter remain an instant without change. Some persons may be disposed to treat with indifference the silent and attenuated influences alluded to, and even to question their reality; yet they are everything in creation. Though no human eye may ever see into their workings, in either slow or fast growing organisms, they are manifest in their effects whenever these swell sufficiently to enter the boundaries that circumscribe our perceptions. It were the essence of absurdity to infer that things cease to be, the instant they elude sensuous organs so gross as ours. Here is a speck of matter so minute as to defy unaided vision: a microscope brings it out to view. But suppose it reduced beyond the power of artificial glasses to detect, it has not therefore vanished into nonentity; on the contrary, it may

and probably does appear a large mass through the natural lenses of animalcules. As it is thus with dimensions, so it certainly is with all other properties and affections of matter.

Then it must be remembered that location is only relative, and it is also only momentary; for while the earth, like every other orb, is ever moving in her orbit, she never sweeps twice over the same track, nor turns twice on her axis in the same circle: two separate bodies can therefore never occupy the same place in space, nor one of them remain over an instant in it. May not the phenomenon in question be therefore ultimately referable to *motion?* As matter cannot rest, its forms cannot be fixed nor the same ones be repeated. At all events, there is no need to suppose, as some have supposed, variety in the constitution of atoms, since the perpetual changes of bodies, as respects their elements, location, and conditions, sufficiently account, not only for interminable modifications of forms and qualities, but for the impossibility of repetition.

On the same principle, the diverse developments which characterize geological epochs, including species and genera, we venture to think, will be accounted for. It was not possible for the primary to be repeated unchanged in secondary formations, nor those of the tertiary to be absolute copies of the seconday. Animals and plants of future periods must inevitably be more or less different from those now on the surface, nor is there any reason to suppose our own species exempt from the prime law of change.

It is unnecessary to add that man can no more than nature produce two things mathematically alike, not even when cast in the same mould. No dyer ever turned out two pieces of silk of exactly the same shade and brilliancy of color, no weaver two webs of uniform texture, and no spinner two yards or two inches of thread that did not differ in many points. As our organs of vision and of touch are limited, so are our ideas of color and coarseness. Were it not so what unhappiness would

arise daily among the sensitive, the fashionable, and proud, from differences and shades of differences, now happily hidden from them. Our perceptive organs suffice for the circle of qualities and conditions recognisable by them, but are no tests for larger or smaller circles. If they equalled those of common flies, how different our standard of delicacy in filamental and textural fabrics, in porosity, smoothness of surface, and everything else!

In this, as in other departments of physics, the GREAT MORAL of science is suggested—viz. To rejoice in our position in the universe and in the possession of the orb assigned us, in our bodily and mental powers and the means provided for their pleasant and profitable employment; assured that, constituted as we are, we can attain a more intimate acquaintance with creation *here* than on any other sphere whatever.

Arrest of condensation—the moon.—P. 68–78.

Whether the specific gravities of the planets diminish with distance from the sun or not, the principle that arrests condensation is not affected one way or the other. It is confined to neither distances nor densities. Orbs of all magnitudes are subject to it, and whether light as cork or heavy as platina. There seems to be but one common condition, and that is *inequality of consistence* and consequently of resistance. This implies defective adhesion, for incoherence as a whole in the material of an orb is indispensable to an interchange of internal and external matter. Were it perfectly consolidated instead of a circulation silent, slow, and continuous, there could be nothing but intermittent and explosive displacements.

But do larger orbs reach their maximum densities sooner than smaller? It may be surmised that they do—that the planets for

example are thus matured in advance of their satellites, and, by analogy, the sun in advance of the planets. The question is however not without its difficulties. When our globe was something less than half a million of miles in diameter the portion constituting the moon was cast off, and the two bodies left to shrink each by itself. The earth retaining by far the largest part of the mass had, we may suppose, the advantage and sooner attained her present dimensions. What time was required for this we cannot imagine. As yet it is useless to attempt speculations on periods of planetary condensation, though data for calculating their comparative durations are doubtless at hand. But passing such matters, if the existing density of the earth was required to be reached before the balance between her internal dilating and her external contracting powers could be established; was an equal or nearly equal density necessary in her satellite? If so, the alleged barren and uninhabited condition of the moon would be accounted for, since her condensation is little more than six-tenths that of the earth. She may be still contracting, though at a rate so slow as to require ages of special observation to detect.

Analogy between animate and artificial motors.—P. 146.

We compare steam power with the fuel expended in its gene ration, and might, on the same principle, deduce the power of living machines from the food they consume, since they are as much subject to laws that govern their strength by their diet, as an iron locomotive whose energies swell and subside with the ignited coal in its furnace. Not that all kinds of food, any more than all kinds of fuel, possess equal virtue, but definite relations exist in all cases between food and force.

The average yield in force of every variety of human aliment has not, we believe, been ascertained. And there is another question—What is the product of the same kind of food when eaten by animals and men? Some people live mostly on rice, others on barley, Indian corn, &c. Do quadrupeds and birds that feed on these cereals derive the same amounts of force from each that we do? Equal force from equal quantities? Or do they differ? A highlander treats his pony to a quart of oats, and himself to the same measure of oatmeal, in a 'crowdie.' What proportion does the *new* force in one bear to that generated within the other? Does the flesh of oxen, deer, sheep, and fowls give out, pound for pound, less or more physical vigor to panthers, wolves, and foxes, than it gives to us? These questions suggest a thousand. If there be, as we suppose, no uniformity of decomposition in food-dissolving apparatuses, nor yet in the electrical and chemical intensities of living forces, what a series of problems has to be solved in relation to stomach structures, their diverse natures, temperatures, powers, and processes!

And were the philosophy of those contrivances for *generating* force mastered, the study of animal mechanics would be but begun. It would be like acquiring some knowledge of boilers without any of engines. There would be material apparently for an eternity of research in the innumerable organisms for *employing* force—in the diversity of their configurations, members, movements, dimensions, substances, and functions; and in their adaptation to the different media they move in. Moreover, should the time ever arrive when man shall have analysed them all, a still higher order of problems awaits him, in the means by which the Will communicates with and makes them do its biddings.